DOCUMENT RESUME

ED 141 080 SE 022 531

AUTHOR Stocker, Carl
TITLE Student Attitudes Toward Science Before and After Introductory College Physics Courses.
PUB DATE Jun 76
NOTE 75p.; Ed.D. Practicum, Nova University; Contains occasional light and broken type

EDRS PRICE MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS *Attitudes; *College Science; *Doctoral Theses; *Educational Research; Higher Education; *Physics; Science Education; *Student Attitudes; Undergraduate Study
IDENTIFIERS Research Reports

ABSTRACT

Attitudes toward science before and after an introductory college physics course were compared for 252 undergraduate students by using a 99-item science attitude survey. Attitudes were found to be favorable before and after the course, but slightly less favorable afterwards. Pre-professional student attitudes were generally favorable. (SL)

Arts Program for Community College Faculty

STUDENT ATTITUDES TOWARD SCIENCE BEFORE AND AFTER INTRODUCTORY COLLEGE PHYSICS COURSES

Carl Stocker

July 1976

Antioch University

STUDENT ATTITUDES TOWARD SCIENCE BEFORE AND AFTER INTRODUCTORY COLLEGE PHYSICS COURSES

by

Carl Stocker, M.S. Physics, M.S. Chemistry

Miami Dade Community College, North Campus

A Major Applied Research Project

Presented in Partial Fulfillment of The Requirements for

The Degree of Doctor of Education in Curriculum and Instruction

Nova University

June, 1976

ACKNOWLEDGEMENT

The author is indebted to his advisors Dr. J. Don Boney, Dr. John Losak, and Dr. Leland L. Medsker for invaluable guidance and assistance in pursuing this research. Without their excellent and pertinent suggestions, the path would certainly have been more tortuous, and the goal, more distant.

Data were collected with the full cooperation of the Miami-Dade Community College North Campus Physics Department and their students in the Fall class of 1975. Especial thanks are due to the Mathematics-Physics Chairperson Bradley Lawrence, and Physics coordinator George Rumsey for their permission to run the study and for their cooperation and interest throughout.

Data processing and evaluation were facilitated under the auspices of the MDCC-North Research Department. Chairperson Gustave Wenzel, John R. Scerba, and Fred Smith all provided service above and beyond the usual call of duty.

The B.A.S.I.C. computer program for data conversion was created and implemented with the assistance of Daniel Brusco. Special appreciation for secretarial help in typing, proof-reading and editorial corrections to Donna Niemeyer.

STUDENT ATTITUDES TO SCIENCE BEFORE AND AFTER INTRODUCTORY COLLEGE PHYSICS COURSES

Carl Stocker

ABSTRACT

A 99-item quintuple-choice science attitude survey was put together for course evaluation. Two previously validated instruments were combined: 1) Evaluations of four concepts, UNIVERSE, SCIENCE, ME IN SCIENCE, and DOING LABORATORY EXPERIMENTS, were estimated by 75 semantic differential type items; 2) Agreements with seven positive and eight negative science attitude statements were measured on an agree-disagree semantic distance basis. Data came from 252 students both before and after all introductory courses of the Miami-Dade Community College-North Physics Department in the Fall 1975 semester. Nine demographic items showed the average student to be a twenty year old male (30% females) with over three years of high-school mathematics and slightly less science, thirty-five completed college credit hours, and total grade point average of 3.1 out of 4.

Research hypotheses were formulated and evaluated as follows: 1) All attitudes would be favorably polarized. Means and standard errors of the items gave evidence of this; 2) There would be no differences in the extents of polarizations of attitudes with respect to independent variables of test timing, before or after the course, or of course group, general education, pre-technical, or pre-professional. T-tests, correlations, and multivariate analysis of variance spanning 28 dependent variables evaluated this.

Answer distributions, pre-post group averages and overall averages were tabulated for each item. Results were categorized as follows: 1) Significantly different attitudes, + or -, as indicated by the sample showing low probabilities of results occurring by chance, and significant t-test differences between means; 2) Significantly similar attitudes, as indicated by the sample showing high p value and a low F ratio of between-groups variance to

within-groups variance; further data would not be expected to reveal any differences here; and 3) Attitudes showing different enough values so that additional data may characterize them as either #1 or #2 above, but undecided by the present data.

Compared as to direction from neutral values, attitude total, factor subtotals, most items, and item clusters were found favorably polarized, and significantly so. Only one sixth the items, and two of ten item clusters, the two on "Ease," were not seen in a favorable light. Semantic distances on positive and negative statements were also measured favorable. Relative positions of all the favored student attitudes about the four concepts were tabulated. "Useful" and "Interesting" were the most favorable of the semantic differential factors describing concepts of SCIENCE, ME IN SCIENCE, and DOING LABORATORY EXPERIMENTS. UNIVERSE was described most favorably on the factors "Beautiful" and "Bright".

Compared relatively, with respect to test timing before or after the courses, most of the twenty-eight dependent attitude factors came under the undecided category. In general, attitudes after courses remained favorably polarized, but measured slightly less so; a second-order effect of testing rather than a true change of attitude was postulated.

Compared relatively, with respect to intergroup differences, many of the attitude factors were found more favorably evaluated by the group of pre-professionals. Significantly lower than overall average, but still favorable evaluations were given by the general education group. Pre-technical group averages seemed in general favorable, but the significance of any differences was obscured by the smallness of the sample compared to other groups.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

Chapter 1

INTRODUCTION

The search for effectual course evaluation methods has led educators to assess student attitudes. Evaluations which are valid, reliable, objective and efficiently swift could provide the feedback needed for course improvement. In the so-called "cognitive" domain of subject matter, such test instruments are fairly easily found or constructed by the individual teacher as an expert in his own area. Yet, to assess the hazier feelings that comprise the "affective" domain, fewer measures pass the muster. Student comments, gut feelings of teachers, and other indicators would all point to attitudes varying at least as widely as knowledge of subject matter.

Real differences in abilities that exist in different student groups, such as mathematical sophistication, could be destructive of self-concept and attitudes. At least as to formal mathematical background, physics departments and textbook authors have taken this into account by offering a less mathematical general education course, a standard pre-technical course, and other pre-professional tracks for engineering-science and for other pre-professional degree candidates. Physics and math exams exist which distinguish these groups, and even indicate whether they are beginning or finishing a given course; proficiency pre-tests and cumulative final exams should be able to accomplish this. But, what attitude inventory could delineate group boundaries? What survey might provide input and guidance for text and course improvement and/or selection? Does the instrument tested herein answer these questions?

Chapter 2

BACKGROUND AND SIGNIFICANCE

SPECIAL PROBLEM AREAS

Site of the Study

The largest campus of Miami-Dade Community College, MDCC-North, numbered about eighteen thousand students in the fall of 1975. This is about half of the total enrollment at this large urban multi-campus institution. Because of growing numbers of evening and other part-time students, full-time equivalent enrollment is somewhat less.

This is the Physics Department at the largest campus of MDCC, a small one for that community college: seven faculty; two secretaries shared with the much larger Mathematics Department; two open laboratories with one supervisor; five introductory courses, but in three basic tracks. 1) General education. Several sections and texts for physical science PHS 101, plus one for descriptive astronomy AST 110; 2) Pre-Technical "Physics with Applications" ASE 163 and associated lab, usually taught from Harris and Hemerlings" Introductory College Physics, 2nd ed. (1972); 3) Pre-Professional: Physics corequiring trigonometry taught from Miller's text College Physics, 3rd ed., (1972); and Physics with Calculus taught from Halliday and Resnick's Physics, 2nd ed. (1973). Four hundred forty students received passing grades for these courses and were possible subjects for this survey. Of thirty-five students in the pre-technical group, pre and post results from twenty are in this study; from about two-hundred in each of the other two groups, pre and post results of 121 and 111 students respectively are reported herein. The MDCC Catalog lists the following courses, including those surveyed in this study:

PHYSICS

ASE 163-164 Physics w/Applications each, 3 credits
Emphasizes the basic concepts and principles and their practical applications. Designed specifically for students in Technical Studies and for others desiring to strengthen their physics background before taking advanced sourses. Corequisites ASE 174-175. Prerequisite or corequisite for ASE 163: MAT 120 or APM 162 or permission of the department chairperson; prerequisite or corequisite for ASE 164: MAT 122 or APM 163 or permission of the department chairperson. (3 hr lecture)

ASE 174-175 Physics w/Applications Laboratory each 1 credit
Laboratory for ASE 163-164. Laboratory fee. (2 hr lab)

AST 110 Descriptive Astronomy 3 credits
The solar system, the nature of electromagnetic radiation, astronomical instruments, stars, galaxies, and cosmology. Several sessions will be devoted to viewing the sky and to laboratory activities. Special fee. (3 hr lecture)

PHS 101 General Education Physical Science 3 credits
Common phenomena, concepts and principles selected from astronomy, physics and chemistry. Special fee. (3 hr lecture)

PHS 102-103 An Approach to Physical Science each, 2 credits
Concepts in physical science selected to give an understanding of how a scientist works and to answer the question, "What is the nature of matter?" Teaching majors are encouraged to take this course as their physical science and General Education requirement. Corequisites: PHS 170-171. (2 hr lecture)

PHS 170-171 Approach/Physical Science Laboratory each 1 credit
Laboratory for PHS 102-103. Laboratory fee. (2 hr lab)

PHY 201-202 Physics each, 3 credits
An introductory course for students requiring a thorough study of the basic principles of physics. Classical mechanics, sound and thermodynamics (PHY 201); electricity, magnetism, and optics (PHY 202). Corequisites: PHY 271-272; prerequisite or corequisite to PHY 201: MAT 122 or permission of the department chairperson; (3 hr lecture)

PHY 271-272 Physics Laboratory each, 1 credit
Laboratory for PHY 201-202. Laboratory fee. (2 hr lab)

PHY 210,211, 212 Physics with Calculus each 3 credits
Foundation course for physical science and engineering majors. Classical mechanics (PHY 210); thermodynamics, wave mechanics, optics, and sound (PHY 211); electricity, magnetism, and modern physics (PHY 212). Corequisites: PHY 273-274-275. Prerequisite or corequisite to PHY 210: MAT 230 or permissi n of the department; prerequisites or corequisites to PHY 211, 212: passing

grade in PHY 210 or permission of the department; corequisite to PHY 211, 212: MAT 231 or permission of the department. (3 hr lecture)

PHY 273,274,275 Physics with Calculus Laboratory each 1 credit
Laboratory of PHY 210-211-212. Laboratory fee. (2 hr lab)

PHY 220 Mechanics 3 credits
Vectors, force systems, equilibrium, friction, centroids, and moments of inertia. Prerequisites: PHY 210, MAT 230 or permission of the department chairperson. (3 hr lecture)

Cultural Variety

An influx of Cuban students at Miami-Dade Community College followed the Castro Cuba catastrophe of the sixties. "Miami is declared first bilingual city in the U. S." flared and blared the Miami Herald to send us off into the seventies. Compounding the communication problem, the United Nations Educational Scientific and Cultural Organization(UNESCO) among other groups has favored sending foreign college students into our higher education system. From Pakistan and Persia, from Israel and India, bilingual dictionaries come into the classrooms. Cross-cultural camaraderie is educational in its own right; but cultural crosswinds that seem refreshing at times, may still be unpredictable in posing problems for production of reliable test instruments. Even single words suffer in translation; and, if one refers to memories of one's foreign language classes, phrases have been known to turn somersaults. Can a simple enough testing instrument be administered and interpreted to give valid, reliable, objective and efficient results, with just the help of a pocket English-foreign language dictionary?

LITERATURE SURVEY

At least since the development of the standard multiple-choice scale from strongly agree to strongly disagree sting has been quantified (Likert, 1932). Common usa re uch ordinal scales as comprised of equal intervals, and at times as representing proportional ratios from a point defined as zero. Placing this zero at one end or the other, or the center permits summations and statistical manipulations otherwise precluded.

Since the development by Likert, refinements have been made in many directions quantitatively and qualitatively in attitude analysis (Jahoda and Warren, 1966; Shaw and Wright, 1967). The concept of attitude itself has been subdivided and placed within a broader domain denominated the affective domain (Krathwohl, et al., 1964). Value and attitude are considered somewhat identically covering at least one centralized subdivision of this domain. These authors give the following hierarchy by analogy with a companion volume which delineates the cognitive domain (Bloom et al., 1956): Affective Domain: "1.0) Receiving: 1.1 awareness, 1.2 willingness to receive, 1.3 controlled or selected attention; 2.0) Responding: 2.1 acquiescence in responding, 2.2 willingness to respond, 2.3 satisfaction in response; 3.0) Valuing: 3.1) acceptance of a value, 3.2) preference for a value, 3.3) commitment; 4.0) Organization: 4.1) conceptualization of value, 4.2 organization of a value system; 5.0 Characterization by a value complex: 5.1) generalized set, 5.2) Characterization." Value and attitudes are therein considered to extend from "willingness to respond (2.2)" to "conceptualization of a value (4.1)."

It may well have been an emotional cry, perhaps descriptive of a fear, love, anger or hate, that started the evolution of human communication. Adjectives as originally used in such a cry are perhaps most fundamentally tied to human feelings. It is perhaps, then, no wonder that attitudes are validly and reliably measured (admittedly along somewhat arbitrary numerical scales,) most often as extending between opposed bipolar adjectives. Take as an example, "On a scale of one to ten, how beautiful is SHE?" Technically, such would be called a "semantic-differential" item, studying the "evaluation" of a "concept" SHE, (traditionally capitalized) by ordinal ranking along an evaluative dimensional factor: "beautiful." Osgood and others at the University of Illinois (Osgood, 1957; Snider and Osgood, 1969; Wernegreen, 1970) have developed and studied this technique extensively. Reproducibly meaningful and voluminously encyclopedic results have been obtained with streamlined format (e.g. UNIVERSE: ugly 1 2 3 4 5 beautiful) and computer assisted statistical techniques (e.g. factor analysis; and multivariate analysis of variance). All cultures and languages seem to have developed adjectives along at least three independent major dimensions. In order of importance, these have been termed evaluation, potency, and activity; other factors, such as stability and novelty are of relatively less predominance, according to findings of the above proponents of the semantic differential technique.

The basic "bad-good" evaluative bipolar adjective pair correlates the most highly with evaluation totals in the definitive studies. But subsidiary evaluative sub-dimensional factors "fun," "useful," "interesting" "safe," and "easy" have received predominant attention by researchers evaluating physics cours eis, 1969; Welch, 1972). The results of their matching th an er adjectives again repeated in this study is listed in Appendix A. This appendix (and similar Tables of this study's results) embodies numerically assessed average attitudes. Columns represent course group and timing as independent variables, in separate formative evaluations (Bloom, 1972) of a PSNS Physical Science for Non-Scientists' text and course (Wood, 1966), and of a Harvard Project Physics' text and course (Geis, 1969; Welch, 1973). Rows represent the evaluative dimensional factors which the subjects ranked along the indicated numerical scale (1 to 7, with 4 = neutral).

The most confidence was apparently expressed as to the usefulness of the concepts DOING LAB EXPERIMENTS, TEACHING SCIENCE, BEING A PHYSICS STUDENT or PHYSICIST. (Other concepts evaluated, but not reported, by these authors were claimed to be less selective and less changed; concepts not involving the students' immediate experiences gave inconclusive results: Geis, 1969.) The low F value (F = between-the-groups variance ÷ within groups variance) here, and for evaluating lab as "easy" bolsters a hypothesis of no differences between groups in the PSNS study. However, low p values do indicate significantly better

evaluations on ME TEACHING SCIENCE for the self-selected PSNS group on the dimensions "safe" and "easy" but lower on evaluating DOING LAB EXPERIMENTS as less"safe." A science attitude inventory (Moore and Sutman, 1970) not of the semantic differential type, also was indicative of more highly favorable attitudes in the PSNS group here. The first Welch (1972) study included [illegible]ght by the author and on[illegible] other colleague [illegible] Miami-Dade Community College. Consequently, his sample and instrument are deliberately and directly overlapping, in a sense, the ones in this study.

Semantic distance from strongly agree to strongly disagree is perhaps the closest method to semantic differential for measuring more differentiated attitudes. (Shaw and Wright, 1967). Instead of merely assessing concepts by the indirect connotations as scaled by semantic differential, here, direct denotations about intellectual and emotional dimensions can be assessed using positive and negative statements. Thus the evaluated range in a postulated continuum of attitudes may be extended by such means, according to Moore and Sutman (1970). They find uncorrelated results between the positive (A) and negative (B) attitudes on the following three-way intellectual (1 to 3) and three-way emotional (4 to 6) dimensions, which were subsequently incorporated wholly in the aforementioned Welch study, and partly in this current work:

1-A The laws and/or theories of science are approximations of truth and are subject to change.

1-B The laws and/or theories of science represent unchangeable truths discovered through science.

2-A Observation of natural phenomena is the basis of scientific explanation. Science is limited in that it can only answer questions about naturla phenomena and sometimes it is not able to do that.

2-B The basis of scientific explanation is in authority. Science deals with all problems and it can provide correct answers to all questions.

3-A To operate in a scientific manner, one must display such traits as intellectual honesty, dependence upon objective observation of natural events, and willingness to alter one's position on the basis of sufficient evidence.

3-B To operate in a scientific manner one needs to know what other scientists think; one needs to know all the scientific truths and to be able to take the side of other scientists.

4-A Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena. Its value lies in its theoretical aspects.

4-B Science is a technology-developing activity. It is devoted to serving mankind. Its value lies in its practical uses.

5-A Progress in science requires public support in this age of science, therefore, the public should be made aware of the nature of science and what it attempts to do. The public can understand science and it ultimately benefits from scientific work.

5-B Public understanding of science would contribute nothing to the advancement of science or to human welfare, therefore, the public has no need to understand the nature of science. They cannot understand it and it does not affect them.

6-A Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work. I would like to do scientific work.

6-B Being a scientist or working in a job requiring scientific knowledge and thinking would be dull and uninteresting; it is only for highly intelligent people who are willing to spend most of their time at work. I would not like to do scientific work.

A 60 item survey based on these ideas led to the following conclusions. Apparently good teaching should both deliberately bolster positive attitudes as well as deny and contradict negative attitudes. Moreover the rejection of negative attitudes averaged only 49 (of 90 range), while acceptance of positive statements averaged 55 over an identical range; people tend to agree with wrong statements they see.

Such possible reaction of subjects to form of test question can be balanced out by certain quasi-experimental research designs involving pre and post-testing (Isaac and Michael, 1971; Kerlinger, 1973; and Tuckman, 1973). Similarly, repetitive testing can and has provided reliability information that has vindicated the tests and methods that were adopted herein (Winer; 1962; Wernegreen, 1971; Moore and Sutman, 1970; Geis, 1969).

RESEARCH QUESTIONS AND HYPOTHESES

The two dominant characteristics of attitudes, their directional polarization and their multidimensionality with respect to any concept, were attended to as follows. The concepts, SCIENCE, ME IN SCIENCE, and DOING LABORATORY EXPERIMENTS were evaluated as to connotations they might have such as, "Useful,""Interesting," "Fun," "Safe," or "Easy,"to the subjects surveyed. In addition, positive and negative statements were considered both separately and together, as part of a scientific attitude inventory (SAI) measuring how closely intellectual and emotional attitudes are aligned with those of scientists and science educators.

And so the dependent variables studied herein were averaged responses to separate items, items clusters, subtotals, and totals representing the aforementioned dimensions of possible attitudes. The independent variables were test timing, before or after the course, and course group, general education, pre-technical or pre-professional. Phrased as a working hypothesis, the first question to be explored was whether:

> 1.) Favorable average attitude polarizations exist, as within each independent variable and as a whole, with respect to numerically neutral positions on each attitude.

In addition two hypotheses were postulated as follows:

> 2.) Average polarizations of attitudes will be the same or will not change significantly with respect to test timing, as to whether before or after the respective courses.

> 3.) Average polarizations of attitudes will be the same or will not be significantly different with respect to which course group, whether general education, pre-technical or pre-professional.

Stated in these terms, questions as to linearity of scale, and of normality of answer distributions were considered not to pose a serious threat to reliability of results. The questions resolved did not measure proportionately how great any differences were, but simply whether they exist, in which direction, and for which attitudes.

Changes in attitude over time, before or after the course, could be at least partially attributed to treatment effects such as the the teacher or the textbook. Lack of change, on the other hand, could attest to reliability of the test instrument. Differences in attitude over the diverse course groups could be reflecting the histories of students as possibly delineated by additional demographic variables.

Chapter 3

PROCEDURES AND METHODOLOGY

A study of available attitude testing instruments and programs led to selection of the composite final instrument shown in Appendix B. The entire seventy-five items in the Welch (1972) Semantic Differential Test had been used with the students in 1970 and yielded significant group to group differences. It was incorporated entirely by merely reducing the possible range of responses from seven to five, which is the maximum number available on Miami-Dade standard test scoring cards. In addition, seven positive, and eight negative judgmental statements (items 76 to 90) were selected from the sixty item Scientific Attitude Inventory which represents both intellectual and emotional scientific attitudes, as developed by Moore & Sutman (1970). The original scale was expanded from its range of four, to the Likert-type (1932) range of five from strongly agree to strongly disagree. Nine demographic items (91 to 99) were appended, modifying them appropriately for the sample's own characteristics. Miami-Dade's Academic Test Scoring cards also had provisions for the students to enter a seven digit identification number, a four digit class sequence number, and a section number to identify the order the cards were administered and to distinguish pretest from posttest.

Cooperation of the entire physics faculty of Miami-Dade Community College-North was then enlisted to survey all their physics classes twice during the fall 1975 semester. Data were taken during the first ten and last ten days of each class, in August and December, respectively.

Data reduction included the following procedures: The randomly distributed half of the items were noted, in which the favorable direction of answer had been reversed (5 to 1 vs. 1 to 5) to avoid response set." All values were re-reversed (aligned) in the direction of high being most favorable, and low being least favorable. Percent favoring each answer, one to five, was calculated and averaged for each item. Simple graphs of these values are shown in Appendix C.

Significant reduction of within-groups variance and its subsequent analysis with respect to many variables (multivariate) was made more feasible by combining intentionally related items additively, and then renormalizing between accepted scale limits. Such items included the following, in order of increasing size: A) Five pairs of three items each, considering "fun, useful, interesting, easy, and safe" as semantic differential factors (attitudes) to evaluate the two "concepts" "DOING LABORATORY EXPERIMENTS" and "ME IN SCIENCE," respectively. "Fun" included "gloomy-joyful, boring-fun, happy-sad;" "Useful" included "important-unimportant, useless-useful, productive-unproductive, and valuable-worthless." Interesting included "interesting-dull, tiresome-exciting, monotonous-stimulating;" "Safe" included "safe-dangerous, threatening-comforting, risky-secure;" "Easy" included "simple-difficult, effortless-demanding, hard-easy." Totals, averaged under each concept, were also calculated, each included fifteen original items; B) Eight negative-attitude, and seven positive-attitude statements, subtotalled and then totalled as representative of the Science Attitude Inventory;

C) An overall total, which [illegible] selected items and from B (above) each 50%, half semantic differential and half science attitude inventory for the 239 student sample showing no missing data.

The hypotheses were pursued that no significant differences would be found between the dependent variables with respect to the independent variables of time and course group. Pre and posttest means, standard deviations and errors of the mean of each group and each variable were calculated and used to implement the appropriate t-tests.

Multivariate analysis of variance, (MANOVA) was performed with the aid of digital computers. Besides the above combined dependent variables, it was possible to do most of the individual semantic-differential items evaluating the concept, "SCIENCE." These additional scales were "historical, philosophical, mathematical, experimental, social, difficult, beneficial, important, and interesting." All the above, and the independent variable of time (a = after, and b = before), were "interval-type." The other and significant independent variable of student group was nominal in nature: 1) general-education, non laboratory physical science students in PHS 101 or AST 101; 2) pre-technical, electrical-electronic and air-conditioning technology students, in ASE 163; and 3) pre-professional students in either PHY 201 or PHY 210. A program by Clyde Computing Services, Coconut Grove, Florida, outputted the desired correlations, p and F values for hypotheses verifications, despite differing numbers of subjects in each subgroup "cell".

Chapter 4

RESULTS

A total of over two hundred thousand individual bits of information were keypunched and processed several times in this study using various computer programs. Significant threads on this loom of data can best be delineated by pursuing, in order, demography, semantic differential analysis, science attitude inventory, item correlations, and discussion.

DEMOGRAPHY

The average student who tendered both identical August and December surveys was a twenty year-old caucasian male, (30% females), who had completed about three years each of high school science and mathematics, in addition to about thirty-five college credit hours. Table I breaks down the data into additional subclassifications. Inferences to other populations would be of firmer validity and use, the closer they approximate this profile. Nevertheless, many of the succeeding results have closely confirmed findings of Geis (1969), Welch (1972) and Wernegreen (1971) who tested physics students at many other institutions of higher learning, with similar testing instruments. The group (#2) of pre-technical students numbered fewer, was all-male, and largely represented an older population of evening students. The other larger groups (#1 and #3) showed similar appreciable, but not predominant, groups of females and of evening students. College population as a whole had greater female representation and was slightly younger.

TABLE 1

DEMOGRAPHIC CHARACTERISTICS OF 252 PHYSICS STUDENTS IN THE STUDY

	Total	General Ed.	Pre-Technical	Pre-Professional
Sample n:	252	121	20	111
Sex:				
Male	70%	68%	100%	71%
Female	30%	32%	0%	29%
Credits completed:				
0-11 (freshman 1)	14%	27%	5%	1.5%
12-23 (freshman 2)	11.5	21	10	1.5
24-35 (sophomore 3)	16.5	17	27.5	14
36-47 (sophomore 4)	24.5	14	20	37
48 or more	33.5	21	37.5	46.5
(Mean hrs.)	(35 hrs.)	(27 hrs.)	(39 hrs.)	(43 hrs.)
High School Mathematics:				
<1 year	2%	0%	3%	4%
<2	10	14	8	6
<3	23	28	18	19
<4	35.5	32	33	40
≥ 4	29	27	38	30
(Mean yrs.)	(3.3 yrs.)	(3.2 yrs.)	(3.4 yrs.)	(3.4 yrs.)
High School Science				
<1 year	5%	7%	5%	3%
<2	20	26	15	14
<3	31	37	35	23
<4	27	23	23	32
≥ 4	17.5	7	22	28
(Mean yrs.)	(2.8 yrs.)	(2.5 yrs.)	(2.9 yrs.)	(3.1 yrs.)
Grade Point Average (A = 4)	(3.1)	(3.0)	(3.0)	(3.2)
Age :				
(Median)	(20)	(19)	(25)	(20)
(Mode)	(20)	(18)	(23)	(21)

SEMANTIC DIFFERENTIAL ANALYSIS

Answer distributions on the semantic differential items are seen to vary considerably from normal Gaussian bell-shaped curves. (Appendix B graphs the total percentages answering each possible answer for all ninety items in sequential order. The answer numbers and averages are re-aligned from the survey's 50% random reversals, to run from one for the least favorable, through the middle (3= neutral), to the highest, five, meaning the most favorable. Averages deemed less favorable than neutral are placed in parentheses. All concepts and scales* in Appendix II are presented in the same verbal order as the survey, with the numerical average placed following the term that the subjects favored. The four concepts UNIVERSE, SCIENCE, DOING LABORATORY EXPERIMENTS, and ME IN SCIENCE each are shown as matched against fifteen or more bipolar adjectives*. These represented five or more evaluative factors (dimensions), inclusive of "fun, useful, interesting, safe, and easy," each as the sum of at least three items.) Similar non-Gaussian distributions were found by Geis (1969). Despite the deviations from normality, totals for the same five factors were analyzed by Welch (1972) using multivariate analysis of variance (MANOVA), the technique pursued in this study for affirmation of proposed hypotheses.

---

*"Concept" nouns, "bipolar" "scale" adjectives, and evaluative "factors" are semantic-differential technical terms, as described in Chapter 2.

Group and pre-post means and Manova (F and p values) results for the five three-scale cumulative factors and their totals with respect to concepts of DOING LABORATORY EXPERIMENTS and ME IN SCIENCE are shown in Tables 2 and 3 respectively. Renormalization here gave a 1 to 7 scale, with 4 representing a neutral attitude. Column headings on these and the following tables represent the independent variables of course group, (C), and timing before or after. Rows were labeled for the dependent variables of renormalized factors (dimensions) and their total, each followed by the computed Manova results of F and p values for course and timing successively. F gives the ratio of the between-the-groups variance to the within-groups variance; p gives the expected probability of the different results occurring by chance. Major effects show high F and low p. The body of the tables give the means values of the dependent variables. Plus and minus signs indicate significant variations from the means as shown by additional T-tests. Table 4 shows some single-scale factor results in a similar format. The adjectives here were polarized by the modifying adverbs "not" as lowest value (1) to "extremely" for the highest value (5). These were not randomized in the original test, and were left off the grand total attitude value to follow on Table 5. Table 6 visually compares the relative positions of all favored student attitudes on all the concepts studied by the semantic differential technique. The most favored attitudes are shown proportionately lower, with the more neutral ones at the start of the table to emphasize the need to work on these. Unfavorable attitudes are inserted inside parentheses.

TABLE 2

STUDENT ATTITUDES TO LABORATORY EXPERIMENTS BEFORE AND AFTER PHYSICS COURSES

CONCEPT: "DOING LABORATORY EXPERIMENTS" (Scale: 1 to 7; Neutral Attitude = 4)

Factor	Mean*	Course(c): General Ed. (Non-Lab Group)	Pre-Technical	Pre-Prof	Timing b = before a = after
Fun	4.562	4.446	4.750	4.646	b
F=1.15; p=.317 for c (F=.537; p=.464 for ab)		4.473	4.722	4.464	a
Useful	5.716	5.802	5.917	5.782	b
F=1.50; p=.224 for c (F=2.34; p=.464 for ab)		5.793	5.778	5.446(-)	a
Interesting	4.899	4.869	4.944	5.032 +	b
F=.221; p=.801 for c F=.784; p=.377 for ab		5.000	4.917	4.682(-)	a
Safe	4.354	4.068(-)	4.306	4.627 +	b
F=16.0; p=.001 for c (F=.067; p=.796 for ab)		4.116	4.639 +	4.573 +	a
Easy	3.520	3.536	3.611	3.473	b
F=1.68; p=.188 for c (F=.021; p=.885 for ab)		3.364(-)	3.972 +	3.618	a
**TOTAL	4.603	4.544	4.706	4.712 +	b
F=1.51; p=.222 for c (F=3.93; p=.048 for ab)		4.551	4.806	4.556	a
Sample n =	239	111	18	110	
Seu # =	±.051	±0.106	±0.264	±0.107	

#Averaged Standard Error expected of each factor mean from the true mean.

Designations +, - indicate significant differences above and below the mean, favorable and unfavorable, respectively.

*± 1.12 = Averaged Standard Deviation about each factor mean.

**± 0.757 = Standard Deviation about total mean.

TABLE 3

STUDENT ATTITUDES TOWARD BEING IN SCIENCE, BEFORE AND AFTER PHYSICS COURSES

CONCEPT: "ME IN SCIENCE: (Scale: 1 to 7; Neutral Attitude = 4)

Factor	Mean*	COURSE GROUP (c) General Ed.	Pre-Tech.	Pre-Prof.	Timing b = before a = after
Fun					
(F=21.8; p=.001 vs c)	4.853	4.586(-)	5.000	5.327+	b
(F=3.69; p=.055 vs ab)		4.360(-)	4.806	5.127+	a
Useful					
(F=24.4; p=.001 vs c)	5.176	4.820(-)	5.556+	5.864+	b
(F=8.04; p=.005 vs ab)		4.586(-)	5.306	5.359+	a
Interesting					
(F=19.3; p=.001 vs c)	4.919	4.734(-)	4.972	5.364+	b
(F=4.11; p=.043 vs ab)		4.324(-)	4.917	5.255+	a
Safe					
(F=6.25; p=.002 vs c)	4.624	4.500(-)	4.667	4.854+	b
(F=1.05; p=.305 vs ab)		4.369(-)	4.917+	4.723	a
Easy					
(F=.432; p=.650 vs c)	3.599	3.676	3.694	3.536	b
(F=.071; p=.789 vs ab)		3.603	3.639	3.559	a
TOTAL**					
(F=20.3; p=.001 vs c)	4.634	4.463(-)	4.778	4.989+	b
(F=5.30; p=.022 vs ab)		4.249(-)	4.717	4.804+	a
Sample: n = 239		111	18	110	
Seu = ± 0.056		±0.117	±0.290	±0.117	

* ± 1.23 = averaged Standard Deviation about each factor mean.

** ± 0.898 = Standard Deviation about the total mean.

Designations +, (-) indicate significant differences above and below the mean, favorable and unfavorable, respectively.

TABLE 4

STUDENT ATTITUDES TOWARD SCIENCE BEFORE AND AFTER PHYSICS COURSES

CONCEPT: "SCIENCE" (Scale: 1 to 5; Neutral Attitude = 3)

Factor	Mean	Course(c): Gen. Ed.	Pre-Tech.	Pre-Prof.	Timing b = before a = after
Historical	3.801	3.955 +	3.722	3.745	b
F = 1.3; p = .274 vs. c		3.721	3.333(-)	3.873	a
F = .65; p = .420 vs. a, b					
Philosophical	3.343	3.378	3.111	3.264	b
F = .45; p = .635 vs. c		3.279	3.278	3.500 +	a
F = .53; p = .469 vs. a, b					
Mathematical	4.358	4.090(-)	4.556 +	4.473 +	b
F = 7.8; p = .001 vs. c		4.279	4.556 +	4.527 +	a
F = 1.9; p = .169 vs. a, b					
Experimental	4.330	4.261	4.556 +	4.418	b
F = 1.3; p = .262 vs. c		4.243	4.333	4.364	a
F = .31; p = 580 vs. a, b					
Social	3.257	3.135(-)	3.667 +	3.309	b
F = 3.9; p = .021 vs. c		3.009(-)	3.278	3.418 +	a
F = .002; p = .965 vs. a, b					
Difficult	3.460	3.324(-)	3.667	3.473	b
F = .77; p = .464 vs. c		3.486	3.444	3.527	a
F = .90; p = .328 vs. a, b					
Beneficial	4.283	4.198	4.222	4.455 +	b
F = 4.1; p = .018 vs. c		4.180	3.944(-)	4.364	a
F = .72; p = .398 vs. a, b					
Important	4.397	4.387	4.444	4.564 +	b
F = 3.7; p = .026 vs. c		4.180(-)	4.500	4.436	a
F = 3.7; p = .055 vs. a, b					
Interesting	4.038	3.865(-)	4.000	4.245 +	b
F = 11.2; p = .001 vs. c		3.775	4.111	4.264 +	a
F = .081; p = .776 vs. a, b					
Sample n:	239	111	18	110	
STD. ERROR		±0.084	±0.209	±0.084	

± 0.884 = Averaged Standard Deviation about each factor mean.

Designations + , (-) indicate significant differences above and below the mean, favorable and unfavorable, respectively.

SCIENCE ATTITUDE INVENTORY

Table 5 renormalizes the mean results from the fifteen selected statements to the 180 range accepted for the original test of Moore and Sutman,(1970). Results for the subdivisions into positive and negative statements are also given. Finally a 50/50 averaging with the totals of Tables 2 and 3 for thirty semantic differential items, was evaluated as an overall score.

In these and in previous subtotalled results, the standard errors of their means appear as smaller fractions of values representing total attitudes. Individual items had much larger comparative errors. As anticipated in theory and now proved in practice, statistical significance is easier to come by with larger groups of items, as well as with larger samples.

One feature of the overall total chosen was that it would revert to neutral value of half its total range under any of the following conditions: 1) A student entered all ones, twos, threes, fours, or fives on his answer card; or 2) A student entered random combinations of all these possible answers such as might be expected from zigzagging answers without really evaluating them; overall averages of such techniques would be expected to cancel out of the final total as a neutral attitude for however many students used them. Reactions of students and proctors to identical posttests certainly could foster boredom and less use of time and care; observed reductions toward neutral of posttest averages are possibly because of this test feature rather than any true changes in attitudes. Wernegreen, (1971) and studies quoted in Appendix A had not noted this probable explanation.

TABLE 5

STUDENT ATTITUDE TOTALED BEFORE AND AFTER TAKING PHYSICS COURSES

15 SCIENCE ATTITUDE INVENTORY STATEMENTS (SAI)

(Likert-rescaled: 0-180 total; 84 for Positive, 96 vs. Negative statements.)

Factor	Courses: (c) General Ed.	Pre-Tech.	Pre-Prof.	Timing b = before a = after
	Mean ± Std. Error of Mean			
SAI Total: F=6.984 p=.001 vs. c. F=.099; p=.753 vs a, b	110.0 ±0.866 (of 180)	107.4(-) 106.1(-)	110.0 107.5	113.2+ 113.7+	b a
For Positives: F=6.203; p=.002 vs c F=2.65; p=.104 vs a, b	56.19 (of 84) ±0.55	54.86 53.45(-)	58.00 55.33	59.18+ 57.16	b a
Against Negatives: F=2.04; p=.131 vs c F=.828; p=.364 vs a, b	53.79 (of 96) ±0.6825	52.54 52.65	52.00 52.17	54.00 56.56	b a
Total Attitude: SAI & Semantic Differential F=15.9; p=.001 vs c F=2.825; p=.093 vs a, b	292.2 ±1.903 (of 480)	283.3(-) 276.0(-)	296.3 293.8	304.9+ 298.8+	b a
Sample n = 239	111	18	110		

Designations +, (-) indicate significant differences above and below the mean, favorable and unfavorable, respectively.

TABLE 6

RELATIVE POSITIONS OF ALL FAVORED STUDENT ATTITUDES ON SCIENCE CONCEPTS

Scale 1 1 to to 5 7	ME IN SCIENCE; DOING LABORATORY EXPERIMENTS	SCIENCE	UNIVERSE
NEUTRAL (3) (4)	(difficult) (hard); secure	simple secure	comforting (dangerous)
4.1			
3.1		(dangerous)[1]	human
4.2	(hard) comforting		knowable
3.2; 4.3	joyful	moral[1] understandable	
4.4			
3.3	comforting	social[1]	
4.5	safe exciting	philosophical[1] clear; fun[1]	friendly
3.4; 4.6	exciting joyful	joyful; (difficult)[1]	
4.7	stimulating	stimulating; knowable	(unpredictable)
3.5	safe; happy	happy	cheerful; joyful
4.8	(demanding)	fun; authoritative exciting	
3.6; 4.9			
5.0			
3.7	important	(mysterious)[1]	old
5.1	fun productive		
3.8; 5.2		historical[1]	
5.3			
3.9	valuable		
5.4	interesting		colorful (mysterious) (changing) alive; bright
4.0; 5.5		interesting[1] (changing)	
5.6		open	
4.1		interesting	
5.7			
4.2; 5.8	valuable	beneficial[1] useful[1]	
5.9		experimental[1]	
4.3	important	productive; mathematical[1]	
6.0		important[1]	beautiful
4.4; 6.1		useful valuable	
6.2			
MOST FAVORED		important	

[1] These scale adjectives were polarized from "Not" to "Extremely"; others were bipolarized vs. antonyms.

CORRELATIONS AMONG DEPENDENT VARIABLES

Correlations between factors, factor clusters and totals processed by multivariate analysis of variance are given in Appendix F. These serve to show up any unexpected relations, and to confirm expected relations among variables combined together. (Listed values at 0.31 or below show greater than 0.05 probability of occurring through chance for the twenty-eight variables calculated (Edwards, 1964: 362), and may be neglected as showing insignificant interrelationships.)

Spurious correlations arise between additively related variables. For example, the overall high total, the total Science Attitude Inventory, (SAI), the subtotals (LAB) and (MY TOT) all show this spurious effect. The fact that the SAI positive and negative statement subtotals are uncorrelated with each other (-0.021), and insignificantly with anything on the semantic differential might be surprising. It would seem to indicate that entirely different variables are measured by it compared to this semantic differential. The intellectual or the emotional judgements its authors (Moore and Sutman, 1970) claim it measures, may in no way be equated to the "connotative meanings" that semantic differential proponents claim (Osgood 1957).

This vindicates the observation by Wernegreen (1971) that two classes of attitudes are in question. His, Geis's (1969), and this semantic differential measure verbal connotations about science, etc.

as the subject that the attitude is evaluating favorably or unfavorably; Warnegreen and Allen's Likert Attitude Test, and Moore and Sutman's Science Attitude Inventory (SAI), used herein, compare agreement with scientific orientations, such as open-mindedness, critical evaluation of causes and effects, etc.

Of the single factors evaluating the concept SCIENCE, "interest" seems the most highly (.278 average) and widely correlated to the factors investigated. Most other single factors used were meant to be independent and as such show low correlations. The .611 intercorrelation of the synonymous terms "important" and "beneficial" is the highest among single factors.

That synonymy leads to high correlations is evident throughout the table. High "interests" in SCIENCE, in ME IN SCIENCE, and LAB go together, as do connotations of "useful," or "fun," or "easy," or "safe." These results confirm the validity of subtotalling factors like "beneficial" and "important" into a cluster like "useful," when applied to a single concept. Of the factor clusters, the three showing the high overall correlations to all other dependent variable, all evaluate the ME IN SCIENCE concept; "interest," "fun," and "useful" here show across-the-board average correlations of .343, .317, and .286 respectively. Correlations among clusters evaluating a single concept like LAB are also appreciable. This justifies the practice of combining them by simple addition to use their total as an overall evaluation of the concept. The computer program in Appendix E was designed to do this as well as to renormalize all combined values to the published scales copied in Appendix A.

DISCUSSION

Favorably Polarized Attitudes

Of the ninety items evaluated, seventy-two showed averages above the neutral value of three. All cumulative dimensions and factors, except for "easy" were in the favorable direction.

The "useful" dimension came out ranking the most favorably polarized. Thus, our subjects most readily rejected adjectives "unimportant," "worthless," "useless," and "unproductive," and accepted as "important," "valuable," "useful," "productive," and "beneficial," the concepts of SCIENCE, DOING LABORATORY EXPERIMENTS, and ME IN SCIENCE.

The next most favorable evaluative dimensions for the above stated concepts were, in decreasing order "interesting," and "fun"; however, "safe" favorably described LAB and ME IN SCIENCE but unfavorably characterized SCIENCE alone, possibly reflecting current controversies in the press over environmental safety, research costs, etc.

Except on the unfavorable "easy" factor, the pre-professional group appeared significantly more favorable in their evaluations of ME IN SCIENCE, (Table 3,) and SCIENCE alone, (Table 4). The general education course subjects rated these slightly less favorable. The probability of these differences in the ME IN SCIENCE results occuring by chance was in general less than one in a thousand ($p < .001$), as was also the total attitude, (Table 5); this latter had been weighted

25% on the fifteen items rating the "LAB" concept and 25% on the fifteen items rating ME IN SCIENCE, about 23% on agreement with seven positive judgemental statements, and 27% on disagreement with eight statements deemed negative.

All in all, as indicated above, the major effect was a predominantly favorable set of subject attitudes towards science. A significantly higher attitude overall, and toward being in science, existed for the pre-professional group. The pre-technical group seemed intermediate to the other groups, slightly, but not necessarily significantly, above average in many cases; too small a sample here allow too high a probability of the favorable results occurring by chance But even the general education group which tested significantly below the sample mean, was still significantly above a neutral attitude. Thus except for across the board agreement that science appeared slightly more than neutral on difficulty, all averages lean toward the favorable side. Table 6 allows a visual comparison between the favored attitudes.

In confirmation of the above results, the powerful technique of a multivariate analysis of variance was used. Thereby it rejected the null hypotheses that the three groups show the same attitudes toward science; this was indicated by the high F values together with the low p values on the Tables 2, 3, 4, and 5. Compared to previous studies summarized in Appendix A, only "ease" of doing laboratory experiments appears less favorable; our experimental open laboratory perhaps should be re-assessed.

Unchanged Attitudes

Low F and high p values would be needed to deny the rejection of the null hypotheses of no differences and/or changes. Results appeared reluctant to deny the null hypothesis that the courses did not change the attitudes that being in science, as well as doing lab experiments would be at least of more than neutral difficulty. The courses also seem not to change any favorable attitudes of safety and interest, one way or the other. The social dimension of science looked especially absent, and also devoid of change. However, in many cases, the null hypothesis can neither be accepted nor rejected without further study; these would have to include either larger samples, further improvements in experimental design, or advances in data treatment.

Changed Attitudes

The dimensional factor, "useful," which was the most favorably polarized and whose use in describing SCIENCE and ME IN SCIENCE differed among the three course groups, - that same factor decreased a small but significantly changed amount from pre to post-test, across the board. Similarly, the next most favorable factors "interesting," and "fun," and the subsequent normalized total, decreased in their evaluation describing ME IN SCIENCE. Nevertheless, these factors still remained by far the most favorably disposed.

The total mean evaluation of DOING LAB EXPERIMENTS decreased an even smaller, but still significantly different amount from before to after for the courses. If it weren't for an insignificant gain in this total for the general education non-laboratory group, the drop might have shown up even more clearly. Appendix A studies show similar changes.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

METHODOLOGY, INSTRUMENTATION AND APPLICATION

This study has determined attitude profiles in the various courses of study in the Miami-Dade Community College Physics Department without a specific treatment or change in treatment in mind; and furthermore, it provided a basis for confirming applicability of past studies with similar testing instruments. It also laid the groundwork for subsequent studies, presently in progress by other researchers in the department. It might have been feared that basically differing profiles and changes might have emerged due to a number of factors. These included the big, growing, but not yet predominant fractions of evening students, of Spanish bilingual students, of students using hand calculators, of health-related major students, and of foreign born students.

None of these factors seemed to affect the results found. The test instrument essentially checked out as a quick, efficient, and discriminating implement for attitude evaluations in college courses. Estimation that ten items could be covered each minute within the semantic differential itself probably would be as high as possible of information transfer efficiency on any instrument; as such it might be more regularly incorporated or appended to other tests given. A quick estimate is that our average college test uses only half the fifty-item maximum capability of the student answer cards provided; at the expense of 2½ more minutes of student time, twenty five semantic differential items could

be added, perhaps on a regular basis. For example, in certain class tests, this author has been interlacing an item-evaluation question, after every test item. The item read, "The above question is 1) VERY SOUND; 2) FAIRLY SOUND; 3) NOT VERY SOUND; or 4) NOT SOUND AT ALL, to make me think constructively and probe fairly my knowledge of related material." A semantic differential might effectively and efficiently separate four factors here. For example the item might read, "The above question seemed (SOUND 1 2 3 4 5 UNSOUND) it made me think (NOT CONSTRUCTIVELY 1 2 3 4 5 CONSTRUCTIVELY); it probed my knowledge of (UNRELATED 1 2 3 4 5 RELATED) material; it did so, (FAIRLY 1 2 3 4 5 UNFAIRLY)."

LINGUISTICS AND SEMANTICS

False statements and polarizations toward them may be a fact of life. Yet B. F. Skinner (1957) has made several allegations against using false statements in his criticism of multiple choice tests; and so perhaps Skinner's operant conditioning theories should be extended to assess verbal behavior on tests of the types in question herein. The almost reflex speed of a semantic differential might make it a natural test of his verbal theories. Psycholinguists, among others disagreeing with Skinner (Snider, 1969) are avid detractors of the Osgood method. Yet the method is generative of sufficiently large amounts of data, so that perhaps refined computerized processing techniques involving statistical communication theory could make significant contributions in the fields of semantics and psycholinguistics.

CONTROVERSIAL ATTITUDES

Several factors that were aligned and/or reversed in the most consistent manner may seem to be controversial in one sense or another. Several of such items concern the first concept UNIVERSE. Items four and six concern novelty and stability respectively, dimensions interpreted as orthogonally independent of evaluation by Osgood (1957); Neither direction is by itself indisputable as the "good" or "favorable" one. It may well be that the universe would be incorrectly interpreted as stable, and not mysterious. Nevertheless, "stability" (6, 25) and "mystery" (9, 66) have both been aligned by considering that SCIENCE should be stable and not mysterious. It would have appeared inconsistent to switch positive direction between the enumerated items. Interpretation of fine effects for UNIVERSE was not a purpose of the test; a warm-up page of some related item has been suggested by Geis (1969: 59) who found low correlations on first trials. Nevertheless, this author's aforementioned bias against a "mysterious," changing" science may be the sole reason for the unfavorable listings of these items with respect to UNIVERSE in Appendices C and D.

Other controversies may also arise, as for example, item three on predictability. It would seem that predictability as a major goal of science, should be listed as favorable. Yet if UNIVERSE is evaluated, perhaps one who sees the present unpredictabilities would become the less complacent, and more motivated scientist.

Item seventy-six showed at least some agreement that "Anything we need to know can be found out through science." (Appendixes C and D.) Scientists in general have not wanted nor sought such a declaration of faith. Yet in this age of misplaced faith in various and sundry cults and psuedo-sciences, perhaps it shouldn't be denigrated that a modicum of trust exists for the institutions of science. Nevertheless, the author has followed the lead of the item developers (Moore and Sutman, 1970) in numbering this attitude unfavorable.

A somewhat related situation appears in the results for item eighty-five (Appendices C and D.): "An important purpose of science is to help man to live longer." Again, the long look down from the ivory tower of science apparently has demanded purity in its priesthood; priests must pray not heal, apparently. But the growing numbers of health-related majors may not see it that way. So, again we follow the "leader," here the "literature" of Moore and Sutman (1970), and label this attitude undesirable.

The same item, eighty-five, could be read to emphasize several different words, and perhaps be interpreted differently each time. Is the purpose important or not? Is it a purpose or not? Is it a purpose of science, scientists, non-scientists, applied scientists, or who, if any specific group? And so on, and so forth.

Even with the simpler structure of the semantic differential, Geis (1969: 66) found similar problems; but here they lent to a more clearcut interpretation. Perhaps the clear and simple structure of the semantic differential is what allows it to remain reliable across cultural and linguistic boundaries. It must be easier to translate three or four basic words and compare them in a repeated format (eg. 1 to 5), than to insert connecting phrases with linguistic connotations that differ in emphasis, if not even in disparate idiomatic denotations.

That SCIENCE, ME IN SCIENCE, DOING LAB EXPERIMENTS are ranked below neutral on the "easy" dimension could be indicative of several factors at work. These might involve the body of scientific knowledge, which has been almost doubling every decade; history and literature increase at much slower paces. The courses might involve the presentation of more science than the underprepared student is capable of assimilating considering course limitations, etc. For example, student absences in a logically progressing course knock out fundamental blocks of knowledge on which succeeding lectures are built; other courses than science probably have less difficulty accomodating for this problem. A student having difficulties for one reason or another is thereby prone to assess SCIENCE, ME IN SCIENCE, and DOING LAB EXPERIMENTS below neutral values on the "hard-easy" scale factors. This could be the case, due to occurences of such circumstances above, as are not under control of science educators.

Perhaps a students' self-concept is less threatened should he rank these concepts successively higher on scales on dimensions of "safe," "fun," "interesting," and "useful." The first two factors here would seem to be more closely related to students' self-concepts. The latter higher-evaluated terms, such as "useful," seem less related. A student could see and admit the utility of science, etc., while committing himself much less than if he had to admit it would be unsafe to have him in science, for example.

IMPORTANT QUESTIONS

The results of this study might point to several questions that could be, or perhaps are, asked of students entering any physics courses. The questions that most separate the various student groups are, in order: Would it be useful for you to be in science? Is being in science fun to you? Is being in science interesting to you? Do you feel it is safe to be doing laboratory experiments? Is science itself interesting to you? Do you feel that science is mathematical? Do you feel the universe is knowable? The conclusions of this study indicate that general education students are apparently less confident of agreeing with these questions, than are the pre-technical and pre-professional majors.

Conversely, science educators may want to ask themselves: Can I give my students better feelings that science and the universe are less mysterious, less dangerous, less changing, and less difficult; and that they are more knowable, more understandable, and more comforting?

BIBLIOGRAPHY

B. Bloom, et al., Handbook of Formative and Summative Evaluation. New York: McGraw-Hill Book Co., 1972.

F. Geis, Jr. The Semantic Differential Technique as a Means of Measuring Change in Affect. Cambridge: Harvard Univ. Doctoral Dissertation, 1969.

S. Isaac and W. B. Michael, Handbook in Research and Evaluation. San Diego: Robert R. Knapp, 1971.

M. Jahoda and N. Warren, Attitudes. Baltimore: Penguin Books Inc., 1966.

F. Kerlinger, Foundations of Behavioral Research (2nd ed.) New York: Holt, Rinehart & Winston, 1973.

D. Krathwohl, et al., Taxonomy of Educational Objectives: Affective Domain. New York: David McKay Co. Inc., 1964.

R. Likert, Technique for Measurement of Attitudes. Arch. Psychol., 140, (1932).

R. W. Moore and F. X. Sutman, The Development, Field Test and Validation of an Inventory of Scientific Attitudes, J. Research in Science Teaching, 1, (1970) 85.

C. E. Osgood, et al., The Measurement of Meaning. Urbana: University of Illinois Press, 1957.

M. C. Shaw and J. M. Wright, Scales for the Measurement of Attitides. New York: McGraw-Hill Book Co., 1967.

B. F. Skinner, Verbal Behavior. New York: Appleton-Century-Crofts, 1957.

J. G. Snider and C. E. Osgood, (eds.) Semantic Differential Technique. Chicago: Aldine Publishing Co., 1969.

R. M. W. Travers (ed.), Second Handbook of Research on Teaching. Chicago: Rand McNally Publishing Co., 1973.

B. W. Tuckman, Conducting Educational Research. New York: Harcourt, Brace & Jovanovich, Inc., 1973.

W. W. Welch, Evaluation of the PSNS Course, J. Research in Science Teaching 9, No., 2, (1972) 139.

W. W. Welch, Review of the Research and Evaluation of Harvard Project Physics, J. Research in Science Teaching 10, No. 4, (1973) 365.

W. W. Welch and M. O. Pella, The Development of an Instrument for Inventorying Knowledge of the Processes of Science, J. Research in Science Teaching 5, 1967-68.

W. W. Welch, Curriculum Evaluation, Review of Educational Research, 39, 1969.

W. W. Welch, H. J. Walberg, and A. Ahlgren, The Selection of a National Random Sample of Teachers for Experimental Curriculum Evaluation, School Science and Mathematics, 49, 1969.

J. O. Wernegreen, An Exploratory Study of Changes in Concepts as Measured by a Semantic Differential Instrument During a College Physical Science Course for Nonscience Students, Urbana: Univ. of Illinois Doctoral Dissertation, 1971.

D. K. Whitla, (ed.) Handbook of Measurement and Assessment in Behavioral Sciences, Reading, Mass.: Addison Wesley Publishing Co., 1968.

B. J. Winer, Statistical Principles in Experimental Design, (2nd ed.) New York: McGraw-Hill Book Co., 1962.

E. A. Wood, Physical Science for Non-Scientists Project at RPI, Amer. J. Phys., 34, 9, 1966.

APPENDIX A

STUDENT ATTITUDES IN PHYSICS COURSES

CONCEPT: DOING LAB EXPERIMENTS

FACTOR Scale: 1 to 7 (Neutral attitude = 4)	COURSE GROUP General Ed.* (no lab) n = 356	PSNS* (with lab) n = 301	HPP** (teachers) n = 720 b n = 684 a	Timing b = before a = after
FUN F* = 1; p* = .44	4.31	4.24		a
USEFUL* (VALUABLE**) F* ≤ 1; p* = .81	5.89	5.87	6.266 5.888	b a
INTERESTING F* = 1.21 p* = .27	3.60	3.66	5.927 5.511	b a
SAFE F* = 6.07 p* = .01	3.95	3.80	4.059 4.352	b a
EASY F* ≤ 1; p* = .78	4.38	4.41	3.011 3.203	b a
Seu	.049	.049	.036	

* Welch, 1972, Multicollege formative evaluation of Physical Science for Non-Scientists Text and Course.

** Geis, 1969, " Harvard Project Physics " Teachers formative evaluations.

APPENDIX A (cont.)

STUDENT ATTITUDES IN PHYSICS COURSES

CONCEPTS

FACTOR	ME TEACHING SCIENCE*		ME AS PHYSICS STUDENT**	BECOMING A PHYSICIST**	TIMING
Scale: 1-7 neutral attitude = 4	General Ed. n = 356	PSNS* n = 301	n = 713 b n = 681 a	n = 721 b n = 684 a	b=before a=after
FUN					
F* = 2.77;	---	---	---	---	b
p* = .09	4.25	4.42	---	---	a
USEFUL*(VALUABLE)					
F* ≤ 1	---	---	5.549	5.728	b
p* = .44	5.90	5.98	4.879	5.269	a
INTERESTING					
F* = 1.27	---	---	5.271	5.193	b
p* = .26	4.67	4.80	4.597	4.779	a
SAFE					
F* = 3.74	---	---	4.498	4.316	b
p* = .05	3.94	4.10	4.396	4.312	a
EASY					
F* = 7.78	---	---	2.790	1.890	b
p* = .005	2.99	3.23	2.307	1.952	a
Seu	.067	.068	.048	.048	

* Welch, 1972, Multicollege formative evaluation of Physical Science for Non-Scientists Text and Course.

** Geis, 1969, " Harvard Project Physics " Teachers Formative evaluations

APPENDIX B

ATTITUDE INVENTORY

A computer pencil should be used. Please bubble in your class sequence and student number on both cards. Turn them over and bubble test section 1 on the 1st, and 2 on the 2nd card. Please answer the following on that 2nd card.

91. Indicate the total college credit hours you've completed: 1) zero to 11; 2) 12 to 23; 3) 24-35; 4) 36-47; 5) 48 or more.

92. Your age is: 1) below 18; 2) 18; 3) 19; 4) 20-25; 5) over 25.

93. Your sex is 1) female; 2) male.

94. Your race is: 1) Black; 2) Spanish surnamed; 3) Oriental; 4) American Indian; 5) Caucasian or other.

95. Your current grade point average (GPA) is: 1) below 2; 2) 2-2.5; 3) 2.51-3; 4) 3.01-3.5 5) 3.51-4.

96. You have completed how many years of high-school math? 1) less than 1; 2) 1-less than 2; 3) 2, less than 3; 4) 3, less than 4; 5) 4 or more.

97. You have completed how many years of high-school science? Same answers as above #96.

98. You have completed how many courses of science related subjects in college? Same answers as above #96.

99. You are currently enrolled in how many <u>other</u> science related courses? Same answers as above #96.

In the following questions, we want to find out how you describe different things. There are no "right" or "wrong" answers, and no part of this test will in any way become part of your course or college record or affect your grades. Please answer to the best of your ability how you feel about each thing, listed as a heading. For example, under a heading CHEMISTRY, you might find a pair of words separated by a scale looking like this: "EASY 1 2 3 4 5 HARD". You are to bubble in how you feel that word pair describes the heading CHEMISTRY. If you feel that CHEMISTRY is very

closely connected with EASY, bubble in #1. If you feel that CHEMISTRY is only somewhat connected with EASY bubble in #2. If you feel that CHEMISTRY is equally connected with EASY and HARD, or not connected with either, bubble in #3. If you feel that chemistry is somewhat or very closely connected with HARD, you would bubble #4 or #5 similarly. We are interested in your first impressions, so work rapidly and do not go back and change any marks. Be sure to check every scale, bubbling it only once.

UNIVERSE

1.	BEAUTIFUL	1	2	3	4	5	UGLY
2.	BRIGHT	1	2	3	4	5	DRAB
3.	UNPREDICTABLE	1	2	3	4	5	PREDICTABLE
4.	NEW	1	2	3	4	5	OLD
5.	DANGEROUS	1	2	3	4	5	SAFE
6.	STABLE	1	2	3	4	5	CHANGING
7.	DEAD	1	2	3	4	5	ALIVE
8.	CHEERFUL	1	2	3	4	5	SAD
9.	MYSTERIOUS	1	2	3	4	5	COMMON
10.	FRIENDLY	1	2	3	4	5	UNFRIENDLY
11.	HUMAN	1	2	3	4	5	MECHANICAL
12.	JOYFUL	1	2	3	4	5	GLOOMY
13.	KNOWABLE	1	2	3	4	5	UNKNOWABLE
14.	GRAY	1	2	3	4	5	COLORFUL
15.	THREATENING	1	2	3	4	5	COMFORTING

SCIENCE

16.	IMPORTANT	1	2	3	4	5	UNIMPORTANT
17.	BORING	1	2	3	4	5	FUN
18.	OPEN	1	2	3	4	5	CLOSED
19.	INTERESTING	1	2	3	4	5	DULL
20.	UNKNOWABLE	1	2	3	4	5	KNOWABLE
21.	VALUABLE	1	2	3	4	5	WORTHLESS
22.	GLOOMY	1	2	3	4	5	JOYFUL
23.	UNDERSTANDABLE	1	2	3	4	5	CONFUSING
24.	TIRESOME	1	2	3	4	5	EXCITING
25	CHANGING	1	2	3	4	5	STABLE
26.	HAPPY	1	2	3	4	5	SAD
27	PRODUCTIVE	1	2	3	4	5	UNPRODUCTIVE
28.	MONOTONOUS	1	2	3	4	5	STIMULATING
29.	USEFUL	1	2	3	4	5	USELESS
30.	CLEAR	1	2	3	4	5	HAZY

DOING LABORATORY EXPERIMENTS

31. IMPORTANT 1 2 3 4 5 UNIMPORTANT
32. GLOOMY 1 2 3 4 5 JOYFUL
33. SAFE 1 2 3 4 5 DANGEROUS
34. INTERESTING 1 2 3 4 5 DULL
35. USELESS 1 2 3 4 5 USEFUL
36. VALUABLE 1 2 3 4 5 WORTHLESS
37. BORING 1 2 3 4 5 FUN
38. TIRESOME 1 2 3 4 5 EXCITING
39. THREATENING 1 2 3 4 5 COMFORTING
40. SIMPLE 1 2 3 4 5 DIFFICULT
41. HAPPY 1 2 3 4 5 SAD
42. MONOTONOUS 1 2 3 4 5 STIMULATING
43. EFFORTLESS 1 2 3 4 5 DEMANDING
44. RISKY 1 2 3 4 5 SECURE
45. HARD 1 2 3 4 5 EASY

ME IN SCIENCE

46. IMPORTANT 1 2 3 4 5 UNIMPORTANT
47. GLOOMY 1 2 3 4 5 JOYFUL
48. SAFE 1 2 3 4 5 DANGEROUS
49. VALUABLE 1 2 3 4 5 WORTHLESS
50. FUN 1 2 3 4 5 BORING
51. TIRESOME 1 2 3 4 5 EXCITING
52. THREATENING 1 2 3 4 5 COMFORTING
53. SIMPLE 1 2 3 4 5 DIFFICULT
54. PRODUCTIVE 1 2 3 4 5 UNPRODUCTIVE
55. HAPPY 1 2 3 4 5 SAD
56. MONOTONOUS 1 2 3 4 5 STIMULATING
57. EFFORTLESS 1 2 3 4 5 DEMANDING
58. RISKY 1 2 3 4 5 SECURE
59. HARD 1 2 3 4 5 EASY
60. INTERESTING 1 2 3 4 5 DULL

SCIENCE

61. NOT HISTORICAL 1 2 3 4 5 EXTREMELY HISTORICAL
62. NOT PHILOSOPHICAL 1 2 3 4 5 EXTREMELY PHILOSOPHICAL
63. NOT MATHEMATICAL 1 2 3 4 5 EXTREMELY MATHEMATICAL
64. NOT EXPERIMENTAL 1 2 3 4 5 EXTREMELY EXPERIMENTAL
65. NOT DANGEROUS 1 2 3 4 5 EXTREMELY DANGEROUS
66. NOT MYSTERIOUS 1 2 3 4 5 EXTREMELY MYSTERIOUS
67. NOT USEFUL 1 2 3 4 5 EXTREMELY USEFUL
68. NOT SOCIAL 1 2 3 4 5 EXTREMELY SOCIAL

69. NOT FUN 1 2 3 4 5 EXTREMELY FUN
70. NOT AUTHORITATIVE 1 2 3 4 5 EXTREMELY AUTHORITATIVE
71. NOT DIFFICULT 1 2 3 4 5 EXTREMELY DIFFICULT
72. NOT MORAL 1 2 3 4 5 EXTREMELY MORAL
73. NOT BENEFICIAL 1 2 3 4 5 EXTREMELY BENEFICIAL
74. NOT IMPORTANT 1 2 3 4 5 EXTREMELY IMPORTANT
75. NOT INTERESTING 1 2 3 4 5 EXTREMELY INTERESTING

On the following questions please answer on the scale:

STRONGLY AGREE 1 2 3 4 5 STRONGLY DISAGREE

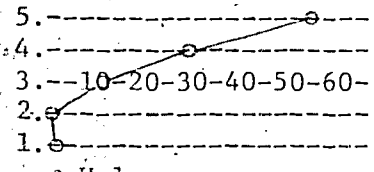
76. Anything we need to know can be found out through science.
77. Scientific explanations can be made only by scientists.
78. Most people are not able to understand the work of science.
79. Scientists cannot always find the answers to their questions.
80. Scientific work would be too hard for me.
81. Some questions cannot be answered by science.
82. Rapid progress in science requires public support.
83. The value in science lies in its theoretical products.
84. Ideas are one of the more important products of science.
85. An important purpose of science is to help man to live longer.
86. Scientific laws cannot be changed.
87. Science is devoted to describing how things happen.
88. Scientists should not criticize each other's work.
89. I would like to work in a scientific field.
90. Scientific laws have been proven beyond all possible doubt.

APPENDIX C

ANSWER DISTRIBUTIONS AND AVERAGES OF EACH ITEM

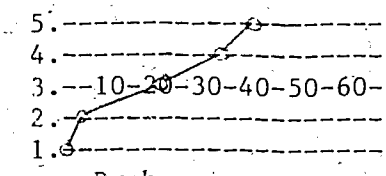
CONCEPT: UNIVERSE

1. Beautiful 4.33



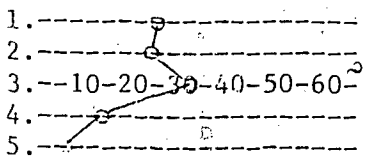
Ugly

2. Bright 4.07



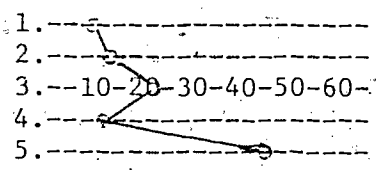
Drab

3. Unpredictable (2.535)



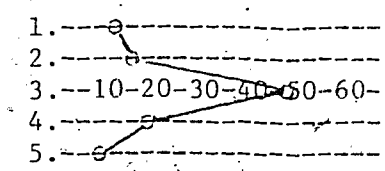
Predictable

4. New



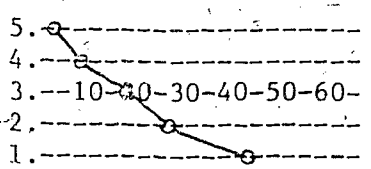
Old 3.71

5. Dangerous (2.965)



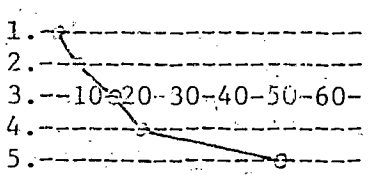
Safe

6. Stable



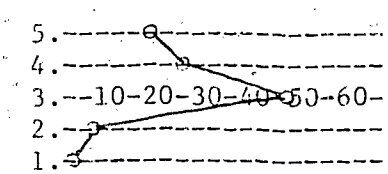
Changing (2.02)

7. Dead



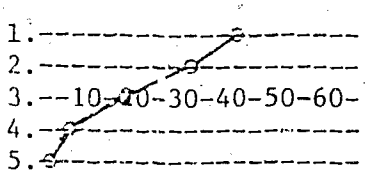
Alive 4.045

8. Cheerful 3.51



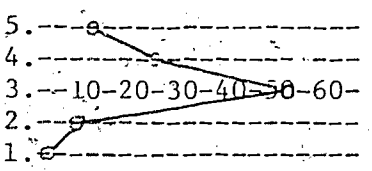
Sad

9. Mysterious (1.99)



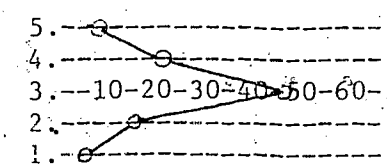
Common

10. Friendly 3.34



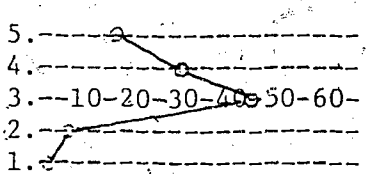
Unfriendly

11. Human 3.10



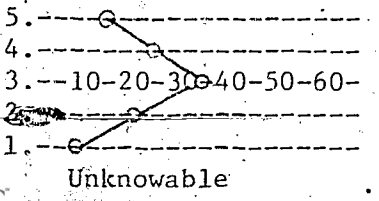
Mechanical

12. Joyful 3.505



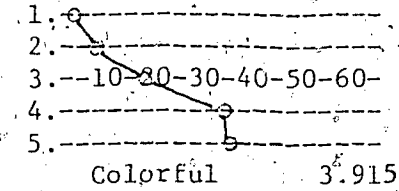
Gloomy

13. Knowable 3.17



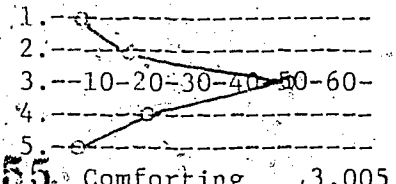
Unknowable

14. Gray



Colorful 3.915

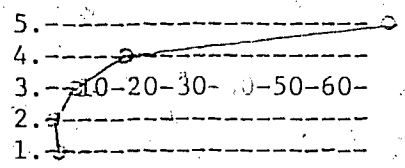
15. Threatening



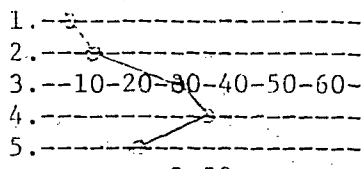
Comforting 3.005

SCIENCE

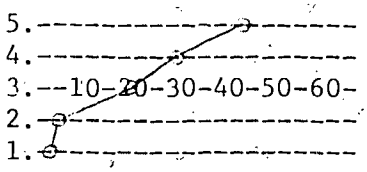
16. Important 4.51



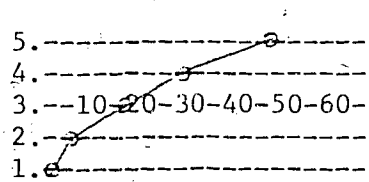
17. Boring



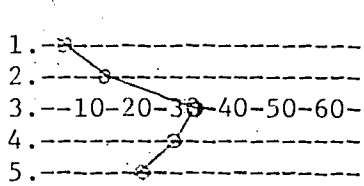
18. Open 4.06



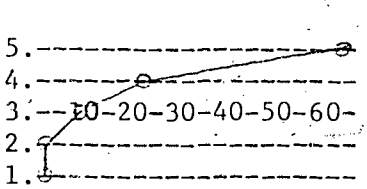
19. Interesting 4.105



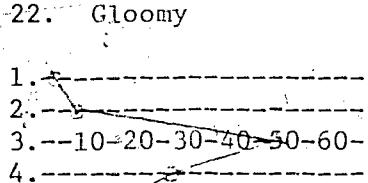
20. Unknowable



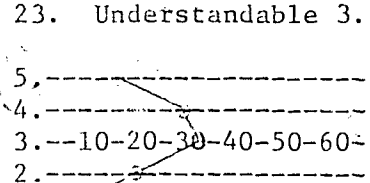
21. Valuable 4.43



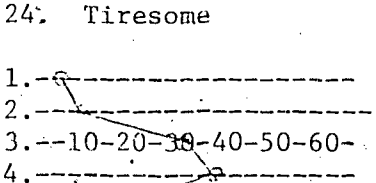
22. Gloomy



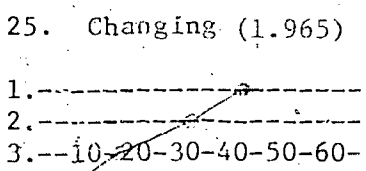
23. Understandable 3.28



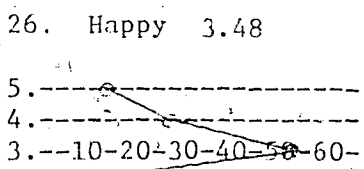
24. Tiresome



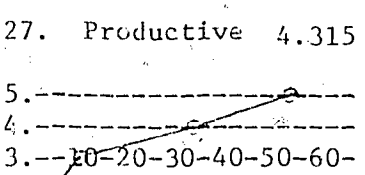
25. Changing (1.965)



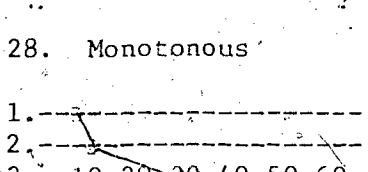
26. Happy 3.48



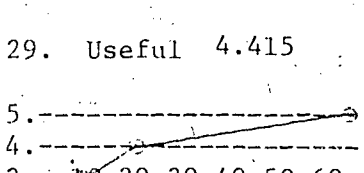
27. Productive 4.315



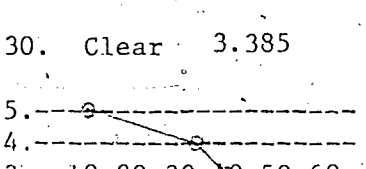
28. Monotonous



29. Useful 4.415

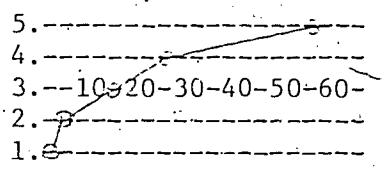


30. Clear 3.385



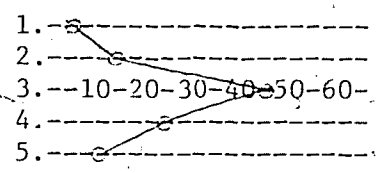
CONCEPT: DOING LABORATORY EXPERIMENTS

31. Important 4.300



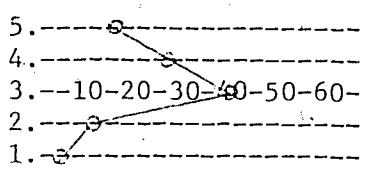
Unimportant

32. Gloomy



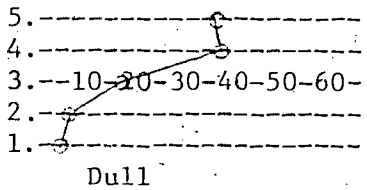
Joyful 3.215

33. Safe 3.36



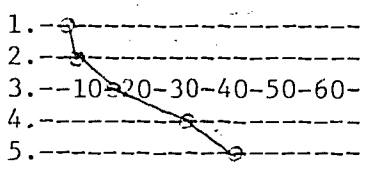
Dangerous

34. Interesting 3.945



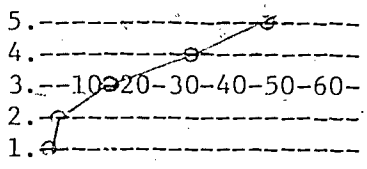
Dull

35. Useless



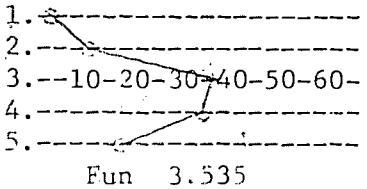
Useful 3.915

Valuable 4.185



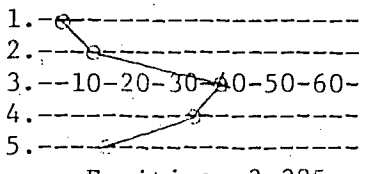
Worthless

37. Boring



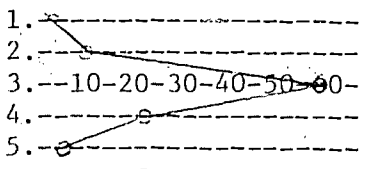
Fun 3.535

38. Tiresome



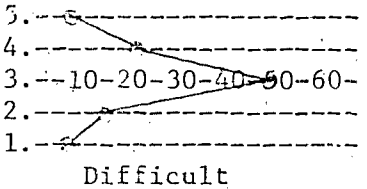
Exciting 3.385

39. Threatening



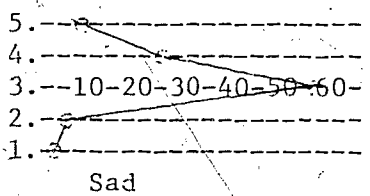
Comforting 3.175

40. Simple 3.005



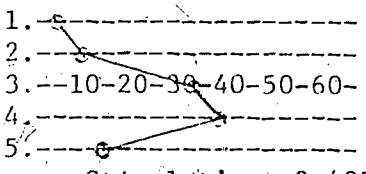
Difficult

41. Happy 3.305



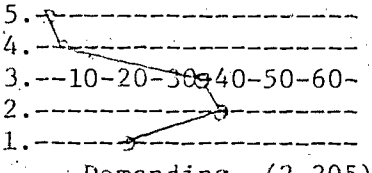
Sad

42. Monotonous



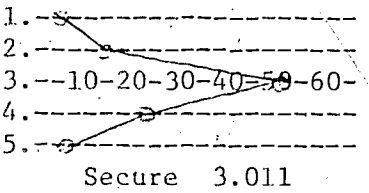
Stimulating 3.485

43. Effortless



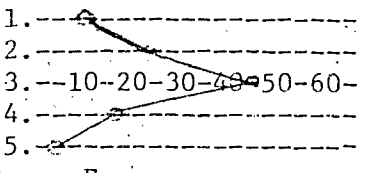
Demanding (2.305)

44. Risky



Secure 3.011

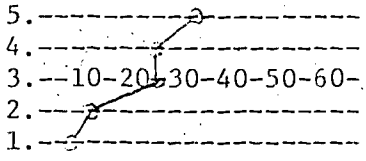
45. Hard (2.835)



Easy

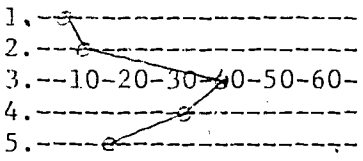
CONCEPT: ME IN SCIENCE

46. Important 3.70



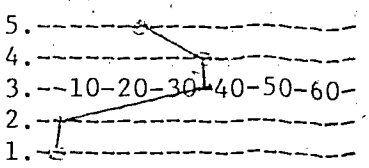
Unimportant

47. Gloomy



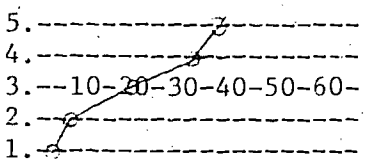
Joyful 3.405

48. Safe 3.53



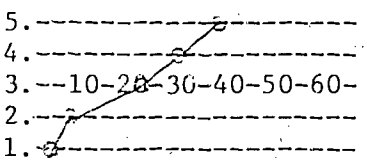
Dangerous

49. Interesting 3.915



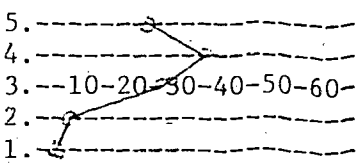
Dull

50. Valuable 3.915



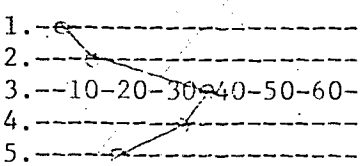
Worthless

51. Fun 3.78



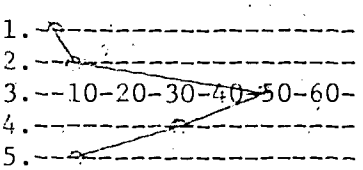
Boring

52. Tiresome



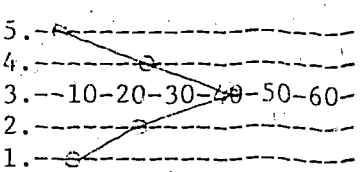
Exciting 3.405

53. Threatening



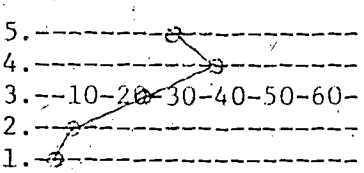
Comforting 3.315

54. Simple



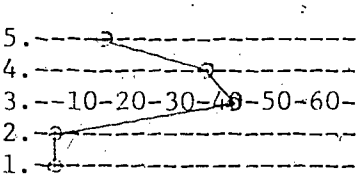
Difficult (2.955)

55. Productive 3.78



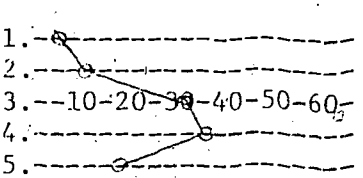
Unproductive

56. Happy 3.53



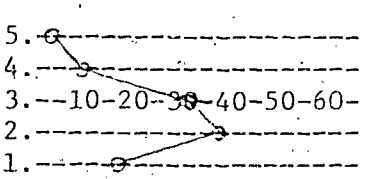
Sad

57. Monotonous



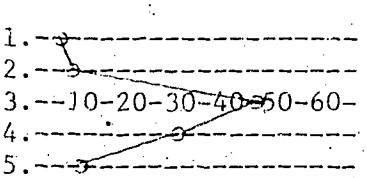
Stimulating 3.495

58. Effortless



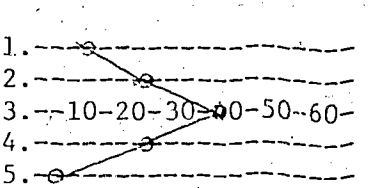
Demanding (2.445)

59. Risky



Secure 3.30

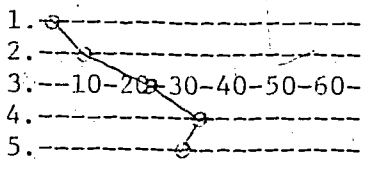
60. Hard (2.865)



Easy

CONCEPT: SCIENCE

61. Not Historical



Extr. Historical
3.78

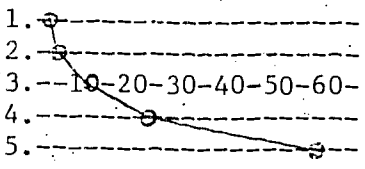
62. Not Philosophical

Extr. Philosophical
3.345

63. Not Mathematical

Extr. Mathematical
4.305

64. Not Experimental



Extr. Experimental
4.295

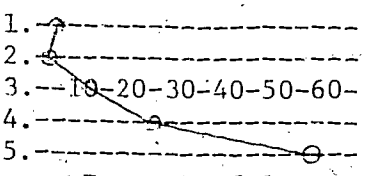
65. Not Dangerous

Extr. Dangerous
(2.90)

66. Not Mysterious

Extr. Mysterious
(2.275)

67. Not Useful



Extr. Useful
4.275

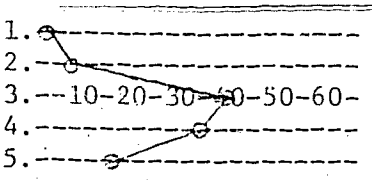
68. Not Social

Extr. Social
3.28

69. Not Fun

Extr. Fun
3.375

70. Not Authoritative



Extr. Authoritative
3.54

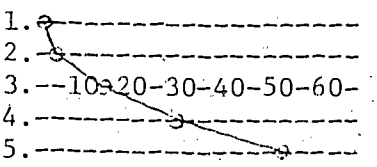
71. Not Difficult

Extr. Difficult
(2.565)

72. Not Moral

Extr. Moral
3.23

73. Not Beneficial



Extr. Beneficial
4.23

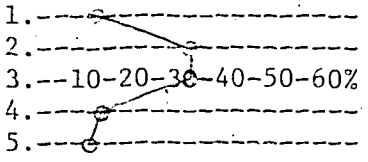
74. Not Important

Extr. Important
4.365

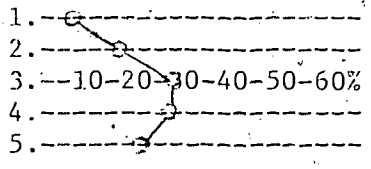
75. Not Interesting

Extr. Interesting
3.98

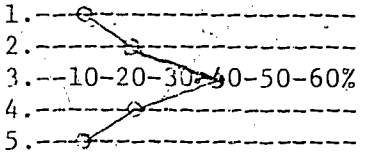
76. Anything we need to know can be found through science. (2.80)



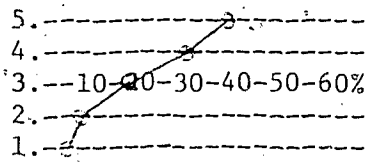
77. Scientific explanations can be made only by scientists. 3.40



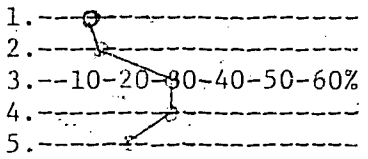
78. Most people cannot understand the work of science. (3.000)



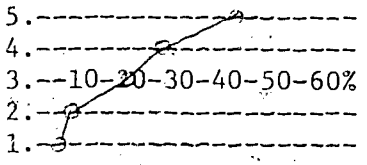
79. Scientists cannot always find answers to their questions. 3.875



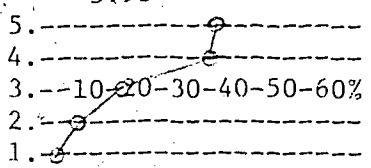
80. Scientific work would be too hard for me. 3.31



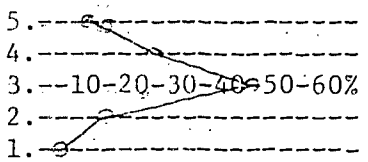
81. Some questions cannot be answered by science. 3.93



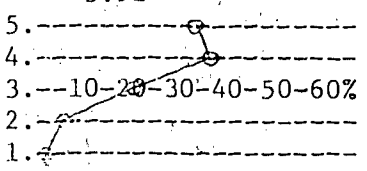
82. Rapid progress in science requires public support. 3.93



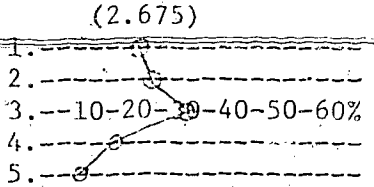
83. The value in science lies in its theoretical products. 3.225



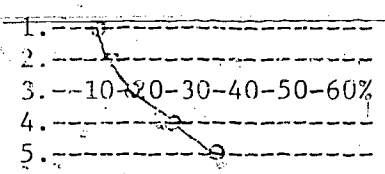
84. Ideas are one of the more important products of science. 3.92



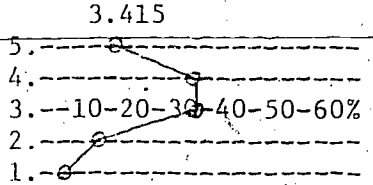
85. An important purpose of science is to help man live longer. (2.675)



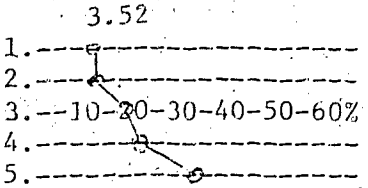
86. Scientific laws cannot be changed. 3.615



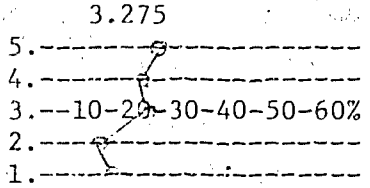
87. Science is devoted to describing how things happen. 3.415



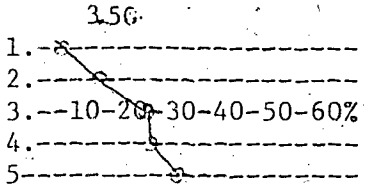
88. Scientists should not criticize each other's work. 3.52



89. I would like to work in a scientific field. 3.275



90. Scientific laws have been proven beyond possible doubt. 3.56



APPENDIX D

GROUP AVERAGES ON FACTORS EVALUATING SCIENCE CONCEPTS

CONCEPT: UNIVERSE

Item No.	Factor and Mean (u) Low = 1 to High = 5 (Neutral = 3)	Course Group General Ed. n = 121	Pre-Tech. n = 20	Pre-Prof. n = 111	Timing b = before a = after
1.	Ugly - Beautiful	3.331	3.250	3.395	b
	u = 4.33	3.322	3.250	3.281	a
2.	Drab - Bright	3.149	3.100	3.886	b
	u = 4.07	3.083	3.150	3.114	a
3.	Unpredictable-Predictable	2.529*	3.000	2.412*	b
	u = 2.535*	2.496*	3.250	2.465*	a
4.	New - Old	3.628	3.700	3.825	b
	u = 3.71	3.562	4.000	3.807	a
5.	Safe - Dangerous	2.893*	2.950*	3.026	b
	u = 2.965*	3.033	3.000	2.886	a
6.	Changing - Stable	2.025*	1.947*	1.877*	b
	u = 2.02*	2.207*	1.800*	1.974*	a
7.	Dead - Alive	3.958	4.300	4.140	b
	u = 4.045	4.058	3.850	4.070	a
8.	Sad - Cheerful	3.463	3.850	3.509	b
	u = 3.51	3.558	3.500	3.482	a
9.	Mysterious - Common	1.793*	2.050*	2.000*	b
	u = 1.99*	2.017*	2.050*	2.149*	a
10.	Unfriendly - Friendly	3.273	3.550	3.439	b
	u = 3.34	3.322	3.250	3.272	a
11.	Mechanical - Human	3.190	3.150	3.158	b
	u = 3.10	2.975*	2.842*	3.149	a
12.	Gloomy - Joyful	3.455	3.650	3.509	b
	u = 3.505	3.521	3.450	3.518	a
13.	Unknowable - Knowable	2.983	3.950	3.123	b
	u = 3.17	3.124	3.600	3.193	a
14.	Gray - Colorful	3.992	4.400	3.868	b
	u = 3.915	3.785	3.700	3.930	a
15.	Threatening - Comforting	2.992*	3.100	2.956*	b
	u = 3.005	2.958*	3.250	3.053	a

* Starred values are below neutral and thus are deemed unfavorable.

APPENDIX D (cont.)

CONCEPT: SCIENCE

Item No.	Factor and Mean (u) Low = 1 to High = 5 (Neutral = 3)	Course Group General Ed. n = 121	Pre-Tech. n = 20	Pre-Prof. n = 111	Timing b = befor a = after
16.	Unimportant -Important u = 4.51	4.545 4.314	4.550 4.400	4.667 4.482	b a
17.	Boring - Fun u = 3.52	3.322 3.256	3.600 3.650	3.746 3.711	b a
18.	Closed - Open u = 4.06	4.066 3.893	4.350 4.100	4.298 3.877	b a
19.	Dull - Interesting u = 4.105	3.843 3.818	4.450 4.150	4.447 4.219	b a
20.	Unknowable - Knowable u = 3.47	3.264 3.322	3.650 3.750	3.667 3.553	b a
21.	Worthless - Valuable u = 4.43	4.421 4.273	4.650 4.650	4.623 4.360	b a
22.	Gloomy - Joyful u = 3.43	3.248 3.208	3.450 3.250	3.693 3.658	b a
23.	Confusing-Understandable u = 3.28	2.959* 3.066	3.500 3.450	3.649 3.430	b a
24.	Tiresome- Exciting u = 3.535	3.275 3.339	3.700 3.550	3.842 3.649	b a
25.	Changing - Stable u = 1.965*	2.033* 2.058*	1.800* 2.000*	1.868* 1.904*	b a
26.	Sad - Happy u = 3.48	3.331 3.358	3.600 3.450	3.596 3.623	b a
27.	Unproductive - Productive u = 4.315	4.215 4.058	4.650 4.500	4.605 4.307	b a
28.	Monotonous-Stimulating u = 3.465	3.446 3.339	3.650 3.500	3.711 3.526	b a
29.	Useless - Useful u = 4.415	4.339 4.190	4.500 4.400	4.693 4.395	b a
30.	Hazy - Clear u = 3.385	3.225 3.225	3.450 3.650	3.506 3.439	b a

* Starred values are below neutral and thus are deemed unfavorable.

APPENDIX D (cont.)

CONCEPT: DOING LABORATORY EXPERIMENTS

Item No.	Factor and Mean (u) Low = 1 to High = 5 (Neutral = 3)	Course Group General Ed. n = 121	Pre-Tech. n = 20	Pre-Prof. n = 111	Timing b = before a = after
31.	Unimportant - Important	4.325	4.350	4.465	b
	u = 4.300	4.380	4.250	4.026	a
32.	Gloomy - Joyful	3.140	3.300	3.95	b
	u = 3.215	3.116	3.350	3.204	a
33.	Dangerous - Safe	3.250	3.300	3.602	b
	u = 3.36	3.099	3.600	3.558	a
34.	Dull - Interesting	3.886	4.050	4.132	b
	u = 3.945	3.967	4.100	3.746	a
35.	Useless - Useful	3.917	4.200	3.912	b
	u = 3.915	3.926	4.000	3.842	a
36.	Worthless - Valuable	4.248	4.400	4.158	b
	u = 4.185	4.264	4.400	4.009	a
37.	Boring - Fun	3.430	3.700	3.623	b
	u = 3.535	3.554	3.650	3.439	a
38.	Tiresome - Exciting	3.397	3.500	3.412	b
	u = 3.385	3.479	3.350	3.219	a
39.	Threatening - Comforting	3.008	3.200	3.263	b
	u = 3.175	3.250	3.250	3.202	a
40.	Difficult - Simple	2.884*	3.100	2.947*	b
	u = 3.005	2.669*	3.300	2.974*	a
41.	Sad - Happy	3.358	3.400	3.289	b
	u = 3.305	3.275	3.300	3.254	a
42.	Monotonous - Stimulating	3.430	3.400	3.491	b
	u = 3.485	3.529	3.400	3.368	a
43.	Demanding - Effortless	2.438*	2.200*	2.202*	b
	u = 2.305*	2.358*	2.400*	2.447*	a
44.	Risky - Secure	2.860*	3.050	3.395	b
	u = 3.011	2.843*	3.500	3.386	a
45.	Hard - Easy	2.769*	3.000	2.825*	b
	u = 2.835*	2.686*	3.300	2.851*	a

* Starred values are below neutral and thus are deemed unfavorable.

APPENDIX D (cont.)

CONCEPT: ME IN SCIENCE

Item No.	Factor and Mean (u) Low = 1 to High = 5 (Neutral = 3)	Course Group General Ed. n = 121	Pre-Tech. n = 20	Pre-Prof. n = 111	Timing b = before a = after
46.	Unimportant - Important	3.355	3.850	4.167	b
	u = 3.700	3.182	3.750	3.754	a
47.	Gloomy - Joyful	3.107	3.750	3.754	b
	u = 3.405	3.116	3.500	3.661	a
48.	Dangerous - Safe	3.570	3.700	3.798	b
	u = 3.530	3.421	3.700	3.640	a
49.	Dull - Interesting	3.769	4.150	4.289	b
	u = 3.915	3.500	3.700	4.114	a
50.	Worthless - Valuable	3.669	4.263	4.325	b
	u = 3.915	3.567	4.100	4.070	a
51.	Boring - Fun	3.620	3.650	4.096	b
	u = 3.780	3.421	3.650	3.886	a
52.	Tiresome - Exciting	3.215	3.400	3.728	b
	u = 3.405	3.017	3.500	3.693	a
53.	Threatening - Comforting	3.207	3.350	3.439	b
	u = 3.315	3.175	3.500	3.407	a
54.	Difficult - Simple	2.950*	3.000	2.982*	b
	u = 2.955*	2.835*	3.105	3.000	a
55.	Unproductive - Productive	3.636	4.200	4.158	b
	u = 3.780	3.438	3.842	3.860	a
56.	Sad - Happy	3.413	3.700	3.798	b
	u = 3.530	3.231	3.500	3.675	a
57.	Monotonous - Stimulating	3.388	3.550	3.719	b
	u = 3.495	3.207	3.450	3.702	a
58.	Demanding - Effortless	2.583*	2.350*	2.283*	b
	u = 2.445*	2.620*	2.350*	2.272*	a
59.	Risky - Secure	3.217	3.350	3.491	b
	u = 3.300	3.107	3.600	3.395	a
60.	Hard - Easy	2.851*	3.100	2.825*	b
	u = 2.865*	2.777*	2.950*	2.877*	a

* Starred values are below neutral and thus are deemed unfavorable.

CONCEPT: SCIENCE

Item No.	Factor and Mean (u) Low = 1 to High = 5 (Neutral = 3)	Course Group General Ed. n = 121	Pre-Tech. n = 20	Pre-Prof. n = 111	Timing b = before a = after
	Not - to - Extremely:				
61.	Historical	3.925	3.684	3.728	b
	u = 3.78	3.681	3.300	3.869	a
62.	Philosophical	3.400	3.053	3.263	b
	u = 3.345	3.231	3.300	3.500	a
63.	Mathematical	4.100	4.526	4.430	b
	u = 4.305	4.215	4.600	4.518	a
64.	Experimental	4.258	4.474	4.404	b
	u = 4.295	4.182	4.350	4.368	a
65.	Dangerous*	3.125*	3.263*	3.132*	b
	u = 3.100*	3.066*	2.800	3.140*	a
66.	Mysterious	3.592*	3.789*	3.903*	b
	u = 3.725*	3.692*	3.600*	3.743*	a
67.	Useful	4.252	4.789	4.404	b
	u = 4.275	4.091	4.450	4.316	a
68.	Social	3.158	3.684	3.316	b
	u = 3.280	3.133	3.400	3.421	a
69.	Fun	3.317	31211	31447	b
	u = 3.375	3.223	3.250	3.553	a
70.	Authoritative	3.471	3.789	3.500	b
	u = 3.540	3.504	3.700	3.684	a
71.	Difficult *	3.288*	3.632*	3.474*	b
	u = 3.435*	3.471*	3.350*	3.535*	a
72.	Moral	3.225	3.474	3.333	b
	u = 3.230	3.150	3.200	3.274	a
73.	Beneficial	4.158	4.158	4.430	b
	u = 4.23	4.125	4.000	4.351	a
74.	Important	4.358	4.474	4.531	b
	u = 4.365	4.150	4.500	4.395	a
75.	Interesting	3.822	4.000	4.219	b
	u = 3.98	3.769	4.150	4.254	a

* On these alone, higher values are less favorable. For lack of exact antonyms, these have not been reversed.

APPENDIX D (cont.)

GROUP PROFILES ON SELECTED ITEMS FROM THE SCIENCE ATTITUDE INVENTORY

ITEMS DEEMED FAVORABLE (POSITIVE)

(Means are re-aligned for high = agreement)

	Overall Total n = 252	Course Group: General Ed. n = 121	Course Group: Pre-Tech. n = 20	Course Group: Pre-Prof. n = 111	Timing b = before a = after
79. Scientists cannot always find the answers to their questions.					
		4.025	3.842	3.939	b
	u = 3.875	3.883	3.900	3.746	a
81. Some questions cannot be answered by science.					
		3.983	3.895	3.851	b
	u = 3.93	3.917	3.900	4.009	a
82. Rapid progress in science requires public support.					
		3.788	3.895	4.079	b
	u = 3.93	3.942	3.850	3.965	a
83. The value in science lies in its theoretical products.					
		3.316	3.158	3.342	b
	u = 3.225	3.202	2.900*	3.132	a
84. Ideas are one of the more important products of science.					
		3.864	4.263	4.140	b
	u = 3.92	3.748	3.850	3.886	a
87. Science is devoted to describing how things happen.					
		3.342	3.632	3.342	b
	u = 3.415	3.420	3.800	3.535	a
89. I would like to work in a scientific field.					
		2.829*	3.579	3.982	b
	u = 3.275	2.546*	3.150	3.770	a

* Starred values are below neutral and thus are deemed unfavorable.

APPENDIX D (cont.)

GROUP PROFILES ON SELECTED ITEMS FROM THE SCIENCE ATTITUDE INVENTORY

ITEMS DEEMED UNFAVORABLE (NEGATIVE)

(Means are re-aligned for high = disagreement)

	Overall Total n = 252	Course Group: General Ed. n = 121	Course Group: Pre-Tech. n = 20	Course Group: Pre-Prof. n = 111	Timing b = before a = after
76. Anything we need to know can be found out through science.					
	u = 2.80*	2.788*	2.737*	2.702*	b
		2.858*	2.750*	2.868*	a
77. Scientific explanations can be made only by scientists.					
	u = 3.40	3.381	3.842	3.272	b
		3.358	3.250	3.535	a
78. Most people cannot understand the work of science.					
	u = 3.00	(2.949)	(2.789)	3.123	b
		(2.950)	3.050	(2.965)	a
80. Scientific work would be too hard for me.					
	u = 3.31	3.127	3.263	3.649	b
		2.883*	3.200	3.658	a
85. An important purpose of science is to help man to live longer.					
	u = 2.675*	2.763*	2.158*	2.561*	b
		2.748*	2.500*	2.702*	a
86. Scientific laws cannot be changed.					
	u = 3.615	3.754	3.579	3.614	b
		3.462	3.500	3.681	a
88. Scientists should not criticize each other's work.					
	u = 3.52	3.466	3.526	3.451	b
		3.607	3.579	3.632	a
90. Scientific laws have been proven beyond possible doubt.					
	u = 3.508	3.365	3.211	3.527	b
		3.542	3.600	3.646	a

* Starred values are below neutral, and thus are deemed unfavorable.

APPENDIX E

BASIC COMPUTER PROGRAM

FOR COMBINING RELATED FACTORS

```
LIST
STOCKR 10:47 AM        19-Mar-76
100   !WRITTEN BY DANIEL BRUSCO:MARCH 2, 1976
200   ON ERROR GOTO 6900
300   DIM A%(80) , B%(160) , A$(160) , B$(80) , D%(8) , E%(160)
400   G%=0
500   OPEN "CR;" FOR INPUT AS FILE 1%
600   INPUT "CARD 'A' OR CARD 'B'";D$
700   IF D$='A' THEN GOTO 800
800 PRINT:PRINT:PRINT
900 PRINT" IDEN.   S   G  P-P F1  U2  I2  S2  E3  M3   T1   T3   T4
     T5    U6  I6  S6  E7  L7  T7  SF  KW HS PH MH EX SC DF BN IM IN"
1000PRINT"-------------------------------------------------------------"
1100 !********BEGIN CARD "A" SUBROUTINE *********
1200 READ A%(I%) FOR I%=1% TO  0%
1300 W%=20%
1400 GOSUB 3600!GO TO EXTRACTION SUBROUTINE
1500 F5=(-5)+5*((6%-D%(6%))+D%(8%)+D%(7%))
1600 U6=(-5)+5*((6%-D%(9%))+(6%-D%(10%))+D%(11%)
1700 I6=(-5)+5*((6%-D%(12%))+D%(13%)+D%(14%))
1800 S6=(-5)+5*((6%-D%(15%))-D%(16%)+D%(17%))
1900 E7=(-5)+5*((6%-D%(18%))+(6%-D%(19%))+D%(20%))
2000 L7=37%-(D%(9%)+D%(15%)+D%(12%)+D%(10%)+D%(6%)+D%(18%)+D%(19%))+
       D%(8%)+D%(11%)+D%(7%)+D%(14%)+D%(16%)+D%(13%)+D%(17%)+D%(20%)
2100 !********BEGIN CARD "B" SUBROUTINE *********
2200 READ B%(I%) FOR I%=1% TO 30%
2300 W%=30%
2400 GOSUB 4200!GO TO EXTRACTION SUBROUTINE
2600 E3=(-5)+5*((6%-E%(24%))+(6%-E%(23%))+E%(25%))
2700 F1=(-5)+5*(D%(1%)+(6%-E%(16%))+(6%-E%(17%)))
2800 U2=5*((6%-D%(2%))+(6%-D%(5%))+(6%-E%(13%)))-5%
2850T3=(486)+2*(42-(E%(9%)+E%(10%)+E%(11%)+E%(12%)+E%(13%)+E%(29%)+
       E%(15%)))
2860T4=(484)+2*(E%(1%)+E%(2%)+E%(3%)+E%(4%)+E%(5%)+E%(6%)+E%(7%)+
       E%(8%))
2900 I2=(-5)+5*((6%-D%(3%))+E%(19%)+E%(20%))
3000 S2=(-5)+5*((6%-D%(4%))+E%(21%)+E%(22%))
3100 M3=49%+E%(19%)+E%(21%)+E%(20%)+E%(22%)+E%(25%)+D%(1%)-(E%
       (23%)+E%(18%)+E%(17%)+E%(24%)+D%(2%)+D%(4%)+D%(3%)+D%(5%)+
       E%(16%))
3170 T5=(M3+L7+T3+T4-20)*2
3180 T1=T3+T4
3200 T7=(T1+2*(L7+M3))
3300 S=E%(28%)
3400 GOSUB 6200!GO TO PRINT-OUT SUBROUTINE
3500 GOTO 1100
3600 !********BEGIN EXTRACTION SUBROUTINE*******
3700  INPUT LINE #1%, A$
3800  INPUT LINE #1%, B$
3900 R%=LEN(A$)
```

```
4000 A$=LEFT(A$,R%-2%)
4100 A$=A$+B$
4200 I$=LEFT(A$,7%)
4250 G$=MID(A$,24%,4%)
4300 P1$=MID(A$,11%,1%):P2$=MID(A$,91%,1%)
4310 S9$=MID(A$,35%,1%)
4320 K9$=MID(A$,43%,1%):CHANGE K9$ TO K9%:K9%=6-(K9%(1%)-48%)
4330 H9%=MID(A$,121%,1%):P9$=MID(A$,122%,1%):M9$=MID(A$,123%,1%)
4340 E9$=MID(A$,124%,1%):R9$=MID(A$,128%,1%):D9$=MID(A$,131%,1%)
4350 B9$=MID(A$,133%,1%):I9$=MID(A$,134%,1%):N9$=MID(A$,135%,1%)
4400 FOR I5=1% TO W%
4500 IF W%=20% THEN 4800
4600 C%=B%(I%)
4700 GOTO 4900
4800 C%=A%(I%)
4900 F$=MID(A$,C%,1%)!EXTRACT VARIABLE
5000 CHANGE F$ TO F%
5100 F%=F%(1)-48 !CONVERT TO ACTUAL NUMBER
5200  IF  F%<0  OR  F%>9  THEN GOTO 5300 ELSE GOTO 5500
5300  print"stu.  #";I$;" left  a  blank  in  column    ";C%"."
5500 IF W%=20% THEN 5800
5600 E%(I%)=F%
5700 GOTO 5900
5800 D%(I%)=F%
5900 NEXT I%
6000 G%=G%+1%
6100 RETURN
6200 !********BEGIN PRINT-OUT SUBRCUTINE********
6300 PRINTI%;S;TAB(1);G$;TAB(16);P1$;P2$;TAB(1);TAB(1);F1;TAB(1);
          U2;TAB(1);I2;TAB(1);S2;TAB(1);E3;TAB(1);M3;TAB(5);T1;
          TAB(1);T3;TAB(1);T3;TAB(1);T5;TAB(1);F5;TAB(1);
6310 PRINTTAB(1);U6;TAB(1);I6;TAB(1); S6;TAB(1);E7;TAB(1);
          L7;TAB(1);T7;
6320 PRINTTAB(1);S9$;TAB(1);K9%;TAB(1);H9$;TAB(1);P9$;TAB(1);
          M9$;TAB(1);
6330 PRINTE9$;TAB(1);R9$;TAB(1);D9$;TAB(1);B9$;TAB(1);N9$
6400 RESTORE
6500 RETURN
6600 DATA 77,76,79,78,80,71,67,62,61,66,65,64,72,68,63,69,
          74,70,73,75
6700 DATA 136,137,138,140,145,146,148,150,139,141,142,143,144,131
6800 DATA 149,111,116,115,112,117,113,119,114,118,120,112,113,153
6850 DATA 147,136,137
6900 CLOSE 1%
7000 END

Ready

RUNNH
CARD 'A' OR CARD 'B'?
```

APPENDIX F

CORRELATIONS AMONG DEPENDENT VARIABLES

VARIABLE:	MY FUN	MY USE	MY INT	MY SAFE	MY EASE	MY TOT	TOT SAI	SAI POS	SAI NEG
MY FUN	*	*	*	*	*	*	*	*	*
MY USE	.614	*	*	*	*	*	*	*	*
MY INT	.735	.639	*	*	*	*	*	*	*
MY SAFE	.429	.328	.468	*	*	*	*	*	*
MY EASE	.280	.107	.213	.272	*	*	*	*	*
MY TOT	.848	.768	.855	.665	.484	*	*	*	*
TOT SAI	.170	.142	.207	.101	-.010	.172	*	*	*
SAI POS	.224	.207	.217	.111	.008	.217	.617	*	*
SAI NEG	.036	.013	.089	.039	-.019	.045	.774	-.021	*
TOTAL	.635	.559	.663	.507	.288	.733	.705	.507	.488
LB FUN	.451	.304	.379	.333	.165	.449	.061	.109	-.010
LB USE	.328	.412	.358	.217	-.026	.366	.201	.227	.073
LB INT	.442	.408	.522	.317	.095	.499	.106	.139	.023
LB SAFE	.215	.128	.252	.488	.201	.340	.054	.065	.016
LB EASE	.141	.059	.065	.231	.497	.257	-.028	-.049	.004
TOT LB	.478	.406	.481	.461	.264	.573	.125	.155	.034
TOT LO	.709	.628	.729	.579	.351	.827	.483	.384	.304
SAFE	.126	.054	.078	.165	.151	.151	-.034	-.066	.010
KNOWABLE	.145	.192	.086	.053	.056	.150	.012	.076	-.046
HISTORIC	.097	.049	.081	.015	-.038	.059	.130	.072	.107
PHILOSOP	.113	.138	.153	.037	.020	.132	.091	.082	.049
MATHEMAT	.018	.051	.141	.086	-.184	.036	.267	.186	.189
EXPERIME	.102	.192	.221	.161	-.149	.153	.255	.231	.139
SOCIAL	.252	.203	.248	.109	.014	.233	.056	.078	.008
DIFFICUL	-.213	-.162	-.226	-.223	-.465	-.345	-.066	-.048	-.045
BENEFICI	.140	.310	.299	.216	-.104	.247	.182	.182	.085
IMPORTAN	.160	.246	.299	.163	-.119	.216	.232	.219	.119
INTEREST	.458	.415	.557	.256	.135	.510	.226	.170	.150

CORRELATIONS AMONG DEPENDENT VARIABLES

VARIABLE:	TOTAL	LB FUN	LB USE	LB INT	LB SAFE	LB EASE	TOT LB	TOT LO	SAFE
TOTAL	*	*	*	*	*	*	*	*	*
LB FUN	.531	*	*	*	*	*	*	*	*
LB USE	.517	.453	*	* *	*	*	*	*	*
LB INT	.585	.741	.598	*	*	*	*	*	*
LB SAFE	.395	.392	.130	.349	*	*	*	*	*
LB EASE	.223	.160	-.134	.071	.342	*	*	*	*
TOT LB	.676	.826	.645	.848	.622	.399	*	*	*
TOT LO	.961	.624	.556	.672	.458	.278	.775	*	*
SAFE	.071	.112	-.039	.061	.152	.188	.134	.092	*
KNOWABL	.123	.090	.127	.113	.080	.114	.158	.144	.063
HISTORI	.123	.038	.143	.126	-.049	-.099	.059	.102	.022
PHILOSO	.147	.063	.107	.115	-.012	.079	.111	.144	.039
MATHEMA	.212	.033	.270	.162	.026	-.244	.087	.160	-.067
EXPERIM	.313	.169	.356	.233	.068	-.193	.202	.292	-.084
SOCIAL	.209	.261	.112	.223	.096	.049	.225	.232	.043
EASE	-.244	-.093	-.007	-.068	-.162	-.330	-.188	-.269	-.094
BENEFIC	.299	.140	.346	.221	.105	-.113	.219	.297	.051
IMPORTA	.297	.112	.317	.172	.043	-.123	.167	.276	-.022
INTEREST	.472	.226	.330	.327	.146	.013	.321	.492	.057

VARIABLE:	KNOWAB	HISTOR	PHILOS	MATHEM	EXPERI	SOCIAL	DIFFIC	BENEFI	IMPORT
HISTOR	-.081	*	*	*	*	*	*	*	*
PHILOS	.044	.366	*	*	*	*	*	*	*
MATHEM	-.110	.249	.112	*	*	*	*	*	*
EXPERI	.038	.114	,078	.547	*	*	*	*	*
SOC	.86	.103	.175	.083	.108				
EASE	-.110	.036	-.022	.155	.065	.063	*	*	*
BENEFI	-.013	.238	.093	.388	.424	.168	.121	*	*
IMPORT	.013	.188	.099	.449	.445	.170	.054	.611	*
INTERE	.064	.135	.181	.238	.303	.267	-.096	.422	.532

May 9, 1976

I certify that I have read and am willing to sponsor this Major Applied Research Project submitted by Carl F. Stocker. In my opinion it conforms to acceptable standards and is fully adequate in scope and quality, as a Major Applied Research Project for the degree of Doctor of Education at Nova University.

J. Don Boney

Dr. J. Don Boney, MARP Advisor
University of Houston,
Houston, Texas 77002

I certify that I have read this Major Applied Research Project Proposal and in my opinion it conforms to acceptable standards of Major Applied Research Project for the degree of Doctor of Education at Nova University.

John Losak

Dr. John Losak, Local Professional

This Major Applied Research Project was submitted to the Central Staff of the Nova University Ed.D. Program for Community College Faculty and is acceptable as partial fulfillment of the requirements for the degree of Doctor of Education.

Leland L. Medsker

Dr. Leland Medsker,
Nova University Central Staff Member
University of California,
Berkeley, California 94704